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Recent Radiometric Dates and Their Implications in Understanding the Early Writing System and Early Historic Archaeology of Tamil Nadu

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Abstract

In Tamil Nadu, nearly 1571 Tamil-Brahmi inscriptions were documented till date from 79 Early Historic sites. Of which nearly 1464 specimens are of Tamil-Brahmi inscribed potsherds recovered from 41 archaeological sites. Irrespective of a large number of Tamil-Brahmi inscriptions, the earliest date could not be assigned to the Tamil-Brahmi script due to the non-availability of the scientific dates. The date of the Tamil-Brahmi script was generally determined based on stratigraphy, palaeography, orthography, linguistic features, internal historical evidences, and other external cultural/trade contacts. The recent archaeological excavations conducted at Iron Age and Tamil-Brahmi yielding Early Historic sites such as Porunthal, Kodumanal, Keeladi, Alagankulam, Adichchanallur and Thelunganur provided 45 radiometric dates. Of the 45 AMS dates, 39 dates belongs to Early Historic sites and remaining 6 are from Iron Age sites. Of the 35 samples (4 contaminated out of 39), 14 dates are assigned to pre-Ashokan (i.e., before 268 BCE) and the earliest date goes back to the sixth century BCE. The metallographic analysis carried out on the sword collected from an Iron Age grave at Thelunganur revealed that it was made of ultra high-carbon steel and yielded two calibrated dates (cal. 1334 BCE and cal. 2742 BCE). Even if one considers the lowermost date as the possible date of introduction of steel, it could be placed around the mid-part of the 14th century BCE. The AMS dates obtained from samples collected from the sites such as Raja Nala-Ka-Tila, Malhar, Lahuradewa, Watgal, Gachibowli, Bukkasagara, Thelunganur and Mangadu placed the manufacture of the iron in India somewhere around the second millennium BCE and steel around the 13th/14th BCE. Thus, the introduction of iron in South India goes back to as early as the second millennium BCE and the beginning of Early historic period, and could safely be placed around the sixth century BCE as the evidence stands today.

Introduction

In ancient India, we have come across three types of writing systems namely Indus, Graffiti and Brahmi writing systems. Among the three, the first and second are yet to be deciphered to the satisfaction of all, irrespective of well-structured methodological approaches. The third writing system, namely the Brahmi, was deciphered with more clarity and accuracy since James Prinsep's decipherment (Salomon 1998: 17-41). Unlike the other two ancient scripts (Indus and Graffiti), the Brahmi script was under the usage for about a thousand years over a wide geographical area, and one could trace the evolution and transformation of the script over the years. After the decipherment of the Ashokan edicts, this script became popular and on account of this, it came to be known as Ashokan-Brahmi or Mauryan-Brahmi, though the language used in the edicts is Prakrit. The Prakrit-Brahmi inscriptions are found in the entire Indian Subcontinent and Sri Lanka except in Tamil Nadu.

The discovery of cave inscriptions in Brahmi script in 1882 by Robert Sewell at Mangulam near Melur in Madurai District of Tamil Nadu could not be deciphered for long as the scholars felt that it was written in the Prakrit language. However, the successful decipherment of the inscriptions in 1924 by K.V. Subrahmanya Aiyer provided a new dimension to the usage of the Brahmi script in another language namely Tamil (Aiyer 1924: 275-300). So as to differentiate from Prakrit-Brahmi, it was designated as Tamil-Brahmi. Unlike Prakrit-Brahmi, the Tamil-Brahmi inscriptions have specific letters to denote retroflex lateral approximant ***ḷ***, retroflex central approximant ***ḻ***, alveolar plosive ***ṟ*** and alveolar nasal ***ṉ***. Further, the letters ***i***, ***ma*** and ***ra*** also have different morphological features and orthographically the conjunct consonants and ligatures are

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absent in Tamil-Brahmi. The specific morphological and orthographic features in addition to the usage of a different language (Tamil) led the scholars to propose a hypothesis that Tamil-Brahmi developed from Prakrit-Brahmi or *vice versa.*

The examination of Jain and Buddhist texts such as *Pannavana-sutta* (second century BCE) and *Lalitavistara* (later than the third century CE) revealed the existence of eighteen and sixty-four scripts respectively that were in practice at the time of their composition. Although we have not come across all the scripts listed in the literature, there is a general agreement among the scholars on the survival of three scripts namely Brahmi, Kharosthi and *Damili (Dravida).* Since both the scripts (Brahmi and *Damili*) find their place in the same literature, it is presumed that both are different and contemporaneous. The close observations of *Damili* (Tamil-Brahmi) and Sri Lankan Brahmi (Prakrit-Brahmi) scripts suggest that *Damili* (Tamil-Brahmi) and Sri Lankan Prakrit-Brahmi had closer relations with each other in terms of palaeography, probably which happened due to the geographical proximity, than the Ashokan Prakrit-Brahmi. Thus, the co-existence of Prakrit-Brahmi and Tamil-Brahmi (*Damili*) generated debate on the origin and date of the scripts.

Fixing the origin and date of Brahmi script eluded the scholars for a long time as they were mostly engraved on non-perishable material such as rock surface, metal objects, and potsherds. The TL/OSL/Archaeomagnetic dating methods to date the inorganic material such as ceramics, bricks, terracotta objects, etc. have limitations. The non-availability of evidence of organic material engraved with Brahmi inscriptions has prevented fixing the date convincingly and scientifically. This situation steered the scholars tentatively to fix the date of inscriptions sailing through the study of palaeography, orthography, archaeological stratigraphy and internal historical moorings. Due to ambiguity, these methods generated much debate among the epigraphists and archaeologists. However, several radiometric dates obtained in a particular stratigraphical or cultural context associated with Brahmi script at the excavated sites of Kodumanal, Porunthal, Alagankulam and Keeladi in Tamil Nadu and also at Anuradhapura and Tissamaharama in Sri Lanka proved useful for fixing the chronology of the script. The fresh radiometric dates provided an academic platform to re-examine the earlier claims and, reassess the entire episode of the Early Historic period.

Previous Investigations

The excavations conducted at Arikamedu, Uraiyur, Karur, Kodumanal, Alagankulam, Vallam, Porunthal, Teriruveli and many other sites provided considerable data to fix the probable date based on the stratigraphical analysis. For instance, Wheeler proposed the date of first and second centuries CE for Arikamedu findings based on the occurrences of imported Roman potteries like amphora jars, Arretine and Rouletted ware (Wheeler 1946: 7-124). Wheeler presumed that Rouletted ware was a Roman ware, whereas the subsequent excavations and analysis suggested that it is purely an Indian ware concentrated mostly in the coastal zones of the Bay of Bengal (Fig. 1). Excavations at Arikamedu pushed the date of Rouletted ware to the second century BCE based on stratigraphical position, pre-dating the Mediterranean ware. Further, Begley (1988: 427-440) considered it as a regional product rather than Roman ware.

The Rouletted ware of Indian origin has been reported from more than 130 sites covering wide geographical areas with much concentration in eastern coastal zones of India and many countries like Egypt, Oman, Yemen, Sri Lanka, Malaysia, Thailand, Indonesia and Vietnam reflecting the contemporary maritime trade and cultural relations with Indian Ocean Rim countries (Fig. 2). Among the overseas countries, the Rouletted ware received special treatment in Sri Lanka, particularly at Tissamaharama, one of the extensively excavated sites for twenty years between 1990 and 2010. Nearly 600 pieces of the Rouletted ware were unearthed at Tissamaharama in different stratigraphical contexts supported with radiometric dates and provided a comprehensive picture on the origin and distribution of the ware (Schenk 2001: 59-195, 2006: 123-52, 2014: 95-115; Pavan and Schenk 2012: 191-202). Tissamaharama findings questioned the hitherto held views on the chronology of South Indian archaeology as most of the Early Historic sites of South India were dated based on Wheeler's assumption that this ware was a Roman ware. The pottery sequences at Tissamaharama representing the period between the fifth century BCE and the 2-13th century CE provided a good picture of the regional development. Pavan and Heidrun Schenk (2012) argued that Rouletted ware, Northern Black Polished ware (NBP), and grey ware of the Gangetic Valley are the ceramics of contemporary period, and they were imported into Sri Lanka and South India along the east coast littoral zones from the lower Gangetic valley of North India. According to her, the plain grey ware first arrived in Sri Lanka in the 5th/4th century BCE, whereas the Rouletted ware entered in the 3rd/2nd century BCE and ceased at about 100 BCE. At Anuradhapura, Rouletted ware is said to have been found even as early as 400-300 BCE. This dating rests on the first emergence of Rouletted ware in Period I with ^{14}C reference ranging from 380-190 BCE (Ford and Coningham 2003: 393-397). Thus, the chronology of the manufacture and distribution of the Rouletted ware falls somewhere between the fourth/third century BCE and first century BCE. Vimala Begley revised the earlier date and placed the appearance of Rouletted ware at Arikamedu to the third/second century BCE (Begley 1988: 427-440, 1996: 12; Begley and De Puma 1991: 157-196). Keeping in view of the emerging

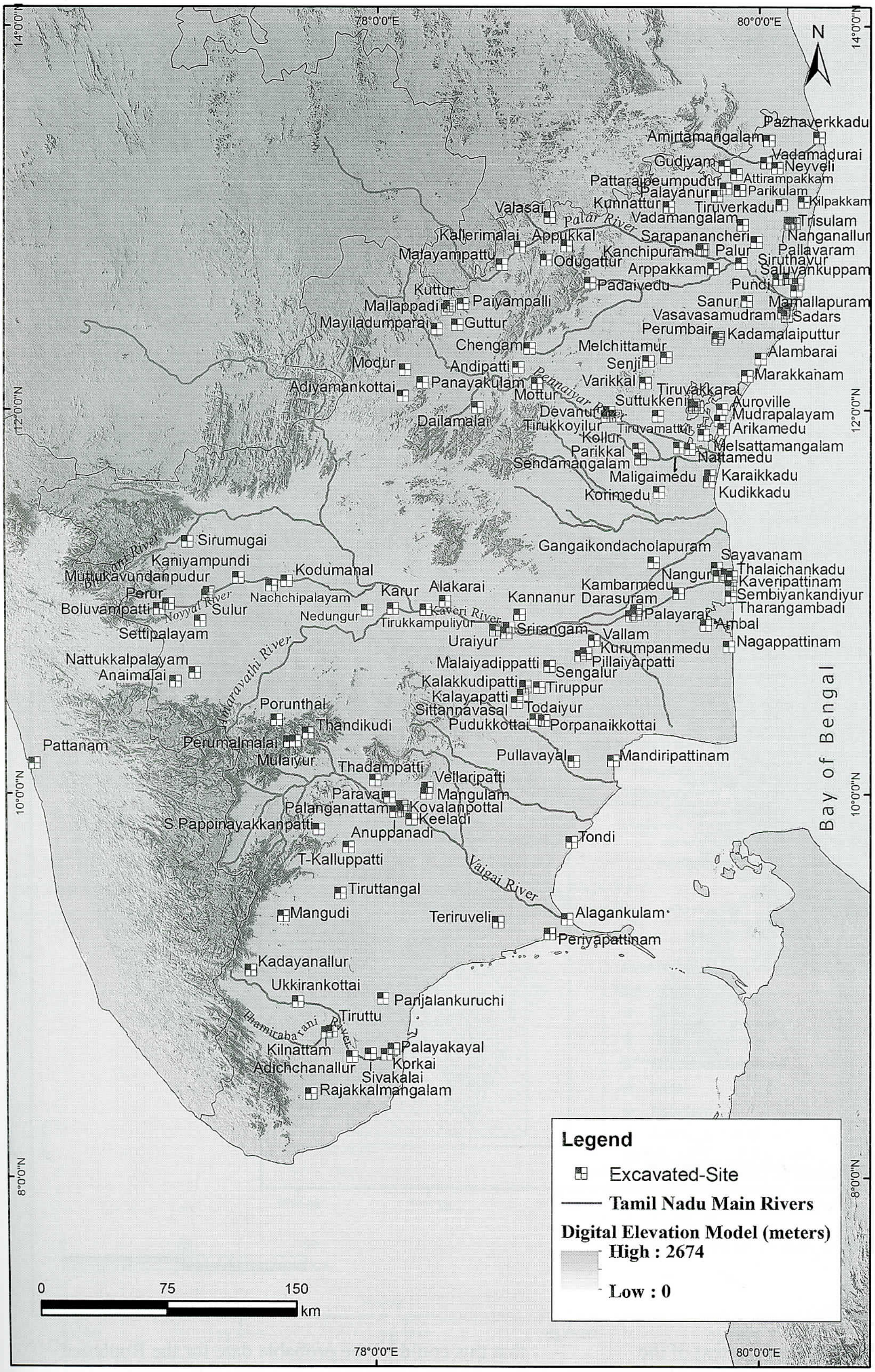

Fig. 1: Excavated sites in Tamil Nadu

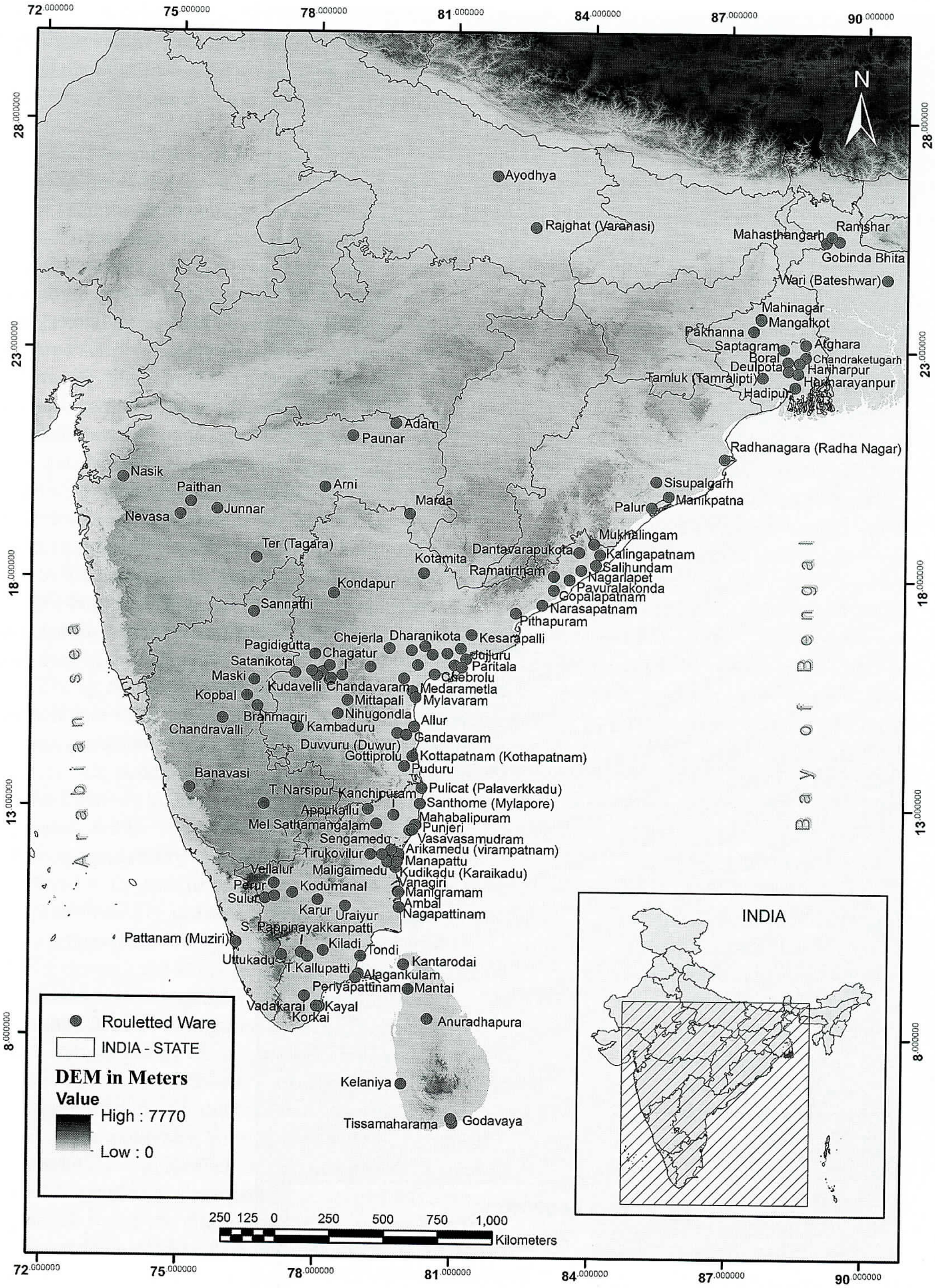

Fig. 2: Archaeological sites with presence of Rouletted ware

evidence, the date of the stratigraphical context of the Rouletted ware also revised at Kodumanal and subsequent AMS dates also supported the conjecture (Rajan 2015: 399-407). The archaeological data recovered from various Rouletted ware yielding sites of Tamil Nadu also suggests that this could be the probable date for the Rouletted ware yielding cultural layers. In contrast to this position, all the find spots of the Rouletted ware were erroneously dated to early first centuries CE assuming it as a Roman ware based on Wheeler's observation. For instance, the

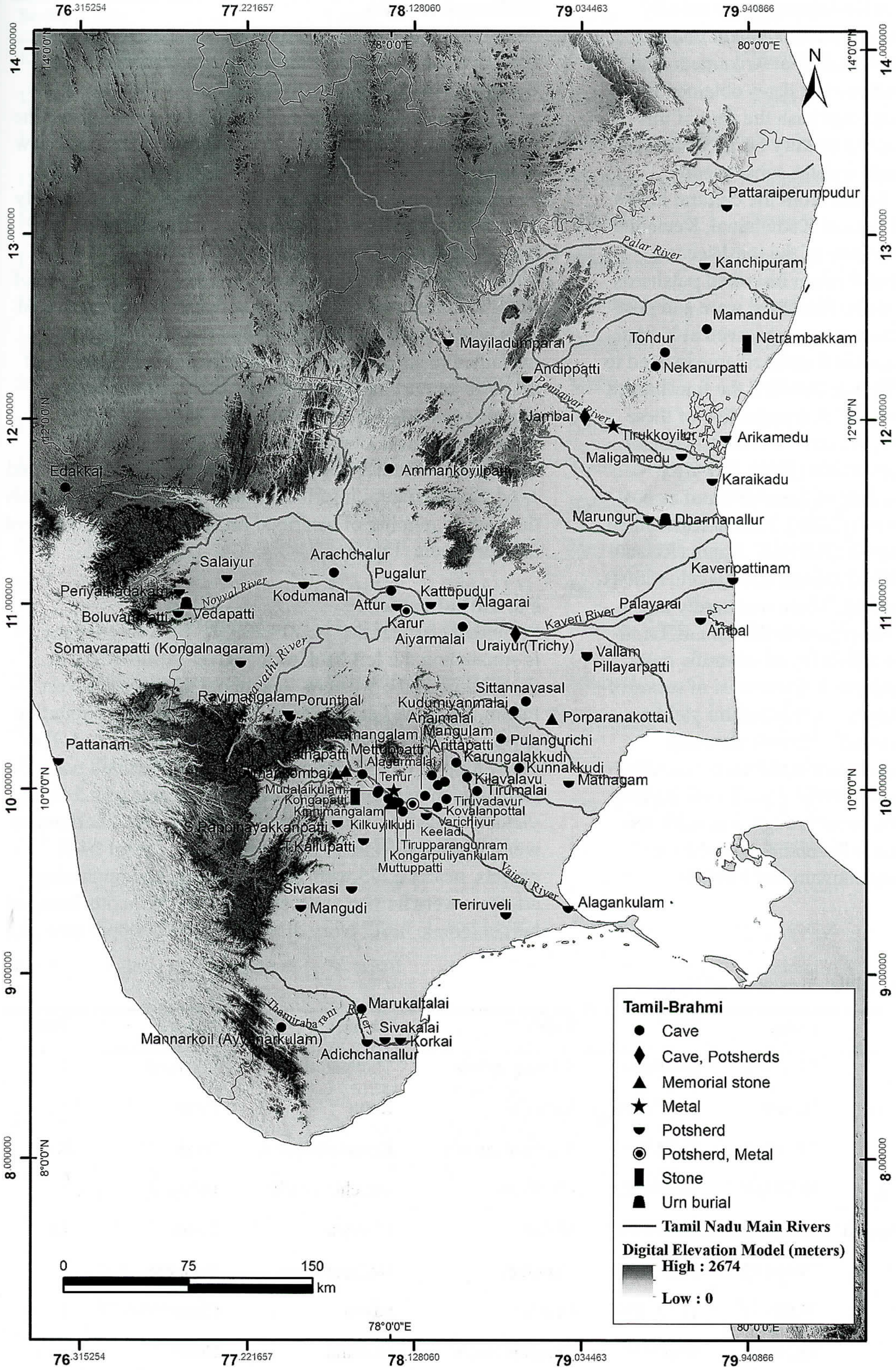

Fig. 3: Archaeological sites yielding Tamil-Brahmi inscriptions

findings of Rouletted ware at Kodumanal were initially dated to first century BCE based on Arikamedu findings (Rajan 1997: 75-77). The revised date at Arikamedu and a considerable number of radiometric dates obtained from Tissamaharama habitation cuttings push the date of this ware as early as the third/second century BCE (Görsdorf 2001: 279-282). The radiometric dates subsequently obtained for the samples collected from the cultural layers that met with the Rouletted ware at Kodumanal, Keeladi and Alagankulam confirm the date of the third/second century BCE. Thus, the Tamil-Brahmi inscribed potsherds unearthed in pre-Rouletted ware, Rouletted ware and post-Rouletted ware cultural context as one observed at Korkai, Alagankulam, Keeladi, Kodumanal and Arikamedu need to be re-examined and re-fix the date between the fourth/third century BCE and first century BCE. Irrespective of these emerging shreds of evidence, the scholars like Iravatham Mahadevan (2014) and Subbarayalu (2008: 209-248, 2014: 115-127) consider the date of Tamil-Brahmi as post-Ashokan whereas K.V. Ramesh (2006), Natana Kasinathan (1998: 152-154), M.D. Sampath (2004), K. Rajan (Rajan and Yathees Kumar 2013: 279-295) and S. Rajavelu (2004) considered them as pre-Ashokan. There was hardly any convergence of views with the regard to the date of Tamil-Brahmi due to limited/non-availability of scientific dates. Now, the picture has changed due to the arrival of series of AMS dates, particularly from the Tamil-Brahmi yielding sites such as Kodumanal, Keeladi, Alagankulam and Porunthal. More than 39 radiometric dates were recently obtained from cultural deposits that yielded Tamil-Brahmi inscribed potsherds. The first breakthrough was achieved in the excavations conducted at Porunthal, and then at Kodumanal followed by Alagankulam and Keeladi.

Radiometric dates

Two AMS dates obtained from Porunthal excavations in 2009 opened the window for the re-examination of the Brahmi script dating. The five AMS dates subsequently received from Kodumanal in 2013 further consolidated the position and forced the re-visit of the previously held view of the third century BCE. The AMS dates of Porunthal and Kodumanal and their implications were extensively discussed elsewhere and are only briefly discussed here (Rajan and Yathees Kumar 2014: 271-276; Rajan 2015: 399-416). Besides these two sites, the sequence of AMS dates obtained subsequently from various excavated sites were tabulated, examined, and the rationale was explained to support the understanding and acceptance of the sixth century BCE date for the early writing system and also to Early Historic period. As on today, nearly 79 archaeological sites yielded 1571 Tamil-Brahmi inscriptions (Table 1). Among them, nearly 41 sites yielded 1464 Tamil-Brahmi inscribed potsherds (Table 2); probably the highest number of inscribed potsherds ever encountered in entire India (Fig. 3).

Porunthal evidence

Porunthal (10° 22' 58" N; 77° 28' 38" E), a tiny village, is situated on the left bank of the River Porunthilaru at the foothill of the Western Ghat about 12 km southwest Palani, the taluk headquarters. The site has both habitation and graveyard evidence of the Early Historic period. The excavation in the habitation mound, locally called *paci-medu* meaning bead mound, covering an area of 5.5 ha, yielded a glass-polishing furnace. In total, 2441 antiquities were recovered from 50 m^2 digging area. Out of 2441 objects, nearly 2275 were of glass beads, and remaining artefacts were human terracotta figurine, terracotta humped bull, a female head, ivory dice, gold piece, copper coin and

Table 1: List of Tamil-Brahmi yielding sites in Tamil Nadu

Sr. No.	Site	Long.	Lat.	Taluk	District	Nature	Total
1	Adichchanallur	77.87527	8.629999	Sri Vaigundam	Thuthukudi	Potsherd	1
2	Aiyarmalai (Ratnagiri)	78.38933	10.877460	Kulitalai	Karur	Cave	1
3	Alagankulam	78.96311	9.355387	Ramanathapuram	Ramanathapuram	Potsherd	73
4	Alagarai	78.39389	10.994722	Thottiyam	Tiruchirappalli	Potsherd	3
5	Alagarmalai (Kidaripatti)	78.22401	10.074360	Melur	Madurai	Cave	13
6	Ambal	79.68422	10.916500	Nannilam	Nagapattinam	Potsherd	1
7	Ammankoyilpatti	77.99350	11.731170	Omalur	Salem	Cave	1
8	Anaimalai	78.18688	9.963310	Madurai North	Madurai	Cave	1
9	Andippatti	78.73889	12.220556	Chengam	Tiruvannamalai	Potsherd	3
10	Arachchalur	77.69242	11.171160	Erode	Erode	Cave	3
11	Arikamedu	79.81926	11.901647	Ariyankuppam	Pondicherry	Potsherd	66

Sr. No.	Site	Long.	Lat.	Taluk	District	Nature	Total
12	Arittapatti	78.29383	10.038760	Melur	Madurai	Cave	2
13	Attur	78.03400	10.989222	Karur	Karur	Potsherd	1
14	Boluvampatti	76.85000	10.950000	Coimbatore South	Coimbatore	Potsherd	1
15	Dharmanallur	79.49232	11.461142	Virdhachchalam	Virdhachchalam	Urn burial	1
16	Edakkal	76.23550	11.626670	Wynad	Wynad	Cave	5
17	Jambai	79.05406	12.015102	Tirukoyilur	Villuppuram	Cave, Potsherds	1
18	Kanchipuram	79.70528	12.837500	Kanchipuram	Kanchipuram	Potsherd	1
19	Karaikadu	79.74585	11.667863	Cuddalore	Cuddalore	Potsherd	1
20	Karungalakkudi	78.35465	10.143330	Melur	Madurai	Cave	1
21	Karur	78.08417	10.964722	Karur	Karur	Potsherd, others	15
22	Kattupudur	78.21768	10.998153	Trichirapalli	Trichirappalli	Potsherd	1
23	Kaveripattinam	79.85889	11.134167	Sirkali	Nagapattinam	Potsherd	1
24	Keeladi	78.19339	9.856545	Manamadurai	Sivaganga	Potsherd	209
25	Kilavalavu	78.41432	10.064270	Melur	Madurai	Cave	1
26	Kilkuyilkudi (Samanarmalai)	78.04425	9.925130	Madurai South	Madurai	Cave	1
27	Kinnimangalam	78.00126	9.924388	Madurai	Madurai	Memorial stone	1
28	Kodumanal	77.52944	11.107500	Perundurai	Erode	Potsherd	991
29	Kongapatti	77.80911	9.959299	Usilampatti	Madurai	Stone	1
30	Kongarpuliyankulam	77.98825	9.945460	Tirmangalam	Madurai	Cave	3
31	Korkai	78.05500	8.641944	Srivaikuntam	Thoothukkudi	Potsherd	8
32	Kudumiyanmalai	78.66808	10.421080	Iluppur	Pudukottai	Cave	1
33	Kunnakkuḍi	78.69701	10.114930	Tiruppattur	Sivaganga	Cave	2
34	Madurai (Kovalanpottal)	78.11889	9.918333	Madurai South	Madurai	Potsherd, others	2
35	Maligaimedu	79.58028	11.803056	Panruti	Cuddalore	Potsherd	8
36	Mamandur	79.71493	12.489190	Cheyyar	Tiruvannamalai	Cave	1
37	Mangudi	77.51361	9.360278	Sankarankoil	Tirunelveli	Potsherd	9
38	Mangulam	78.25589	10.020650	Madurai North	Madurai	Cave	6
39	Mannarkoil (Ayyanarkulam)	77.40839	8.709340	Ambasamudram	Tirunelveli	Cave	2
40	Marukaltalai	77.84333	8.809100	Tirunelveli	Tirunelveli	Cave	1
41	Marungur	79.40028	11.461944	Panruti	Cuddalore	Potsherd	3
42	Mathagam	78.96667	10.033333	Aranthangi	Pudukottai	Potsherd	1
43	Mayiladumparai	78.31333	12.420000	Krishnagiri	Dharmapuri	Potsherd	2
44	Mettuppatti	77.84669	10.079890	Nilakottai	Dindugul	Cave	10
45	Mudalaikulam	77.92986	9.978490	Usilampatti	Madurai	Cave	1
46	Muttuppatti	78.02169	9.929900	Madurai South	Madurai	Cave	3

Sr. No.	Site	Long.	Lat.	Taluk	District	Nature	Total
47	Nekanurpatti	79.43719	12.288610	Gingee	Villuppuram	Cave	1
48	Netrambakkam	79.93382	12.411849	Madurandagam	Kanchipuram	Stone	1
49	Palayarai	79.35000	10.933333	Kumbakonam	Thanjavur	Potsherd	1
50	Pattanam	76.20019	10.150381	Thrissur	Thrissur	Potsherd	3
51	Pattaraiperumpudur	79.82372	13.151931	Tiruvallur	Tiruvallur	Potsherd	14
52	Periyathadakam	76.85417	11.065549	Periyanayakkanpalayam	Coimbatore	Potsherd	1
53	Pillayarpatti	79.06500	10.729471	Thanjavur	Thanjavur	Potsherd	1
54	Porparanakottai	78.87437	10.381220			Memorial stone	1
55	Porunthal	77.45670	10.389170	Palani	Dindugul	Potsherd	1
56	Pugalur	78.00222	11.073889	Karur	Karur	Cave	12
57	Pulangurichi	78.59895	10.273430	Ponnamaravathi	Sivaganga	Cave	1
58	Pulimankombai	77.70389	10.084170	Andipatti	Teni	Memorial stone	3
59	Ravimangalam	77.44361	10.410252	Palani	Dindugul	Potsherd	1
60	S.Pappinayakkanpatti	77.71389	9.816111	Peraiyur	Madurai	Potsherd	1
61	Salaiyur	77.11235	11.143856	Palladam	Coimbatore	Potsherd	1
62	Sittannavasal	78.73332	10.473500	Iluppur	Pudukottai	Cave	1
63	Sivakasi	77.79037	9.458915	Sivakasi	Virudhunagar	Potsherd	1
64	Sivakalai	77.97810	8.638710	Sri Vaikundam	Thuthukudi	Potsherd	1
65	Somavarapatti (Kongalnagaram)	77.18765	10.678901	Palladam	Erode	Potsherd	1
66	T.Kallupatti	77.85389	9.719444	Peraiyur	Madurai	Potsherd	1
67	Tenur	78.01917	9.994444	Madurai North	Madurai	Others	7
68	Teriruveli	78.62508	9.320379	Mudukulathur	Ramanathapuram	Potsherd	7
69	Thathapatti	77.75813	10.099850	Nilakottai	Dindugul	Memorial stone	1
70	Tirukkoyilur	79.20825	11.966364	Tirukkoyilur	Villuppuram	Others	1
71	Tirumalai	78.46822	9.990480	Sivaganga	Sivaganga	Cave	2
72	Tirupparangunram	78.06605	9.878270	Madurai South	Madurai	Cave	3
73	Tiruvadavur	78.30190	9.945360	Melur	Madurai	Cave	2
74	Tondur	79.48844	12.364050	Gingee	Villuppuram	Cave	1
75	Uraiyur (Tiruchirappalli)	78.67611	10.837778	Srirangam	Tiruchirappalli	Cave, Potsherds	21
76	Vallam	79.06528	10.716389	Thanjavur	Thanjavur	Potsherd	4
77	Varichiyur	78.25363	9.902710	Madurai North	Madurai	Cave	3
78	Vedapatti	76.89231	11.002400	Coimbatore South	Coimbatore	Urn burial	1
79	Vikkiramangalam	77.93450	9.989570	Usilampatti	Madurai	Cave	6
	Total						1571

Table 2: List of sites yielding Tamil-Brahmi inscribed potsherds

Sr. No.	Site	Long.	Lat.	Taluk	District	Total
1	Adichchanallur	77.87527	8.629999	Sri Vaigundam	Thuthukudi	1
2	Alagankulam	78.96311	9.355387	Ramanathapuram	Ramanathapuram	73
3	Alagarai	78.39389	10.994722	Thottiyam	Tiruchirappalli	3
4	Ambal	79.68422	10.916500	Nannilam	Nagapattinam	1
5	Andippatti	78.73889	12.220556	Chengam	Tiruvannamalai	3
6	Arikamedu	79.81926	11.901647	Ariyankuppam	Pondicherry	66
7	Attur	78.03400	10.989222	Karur	Karur	1
8	Boluvampatti	76.85000	10.950000	Coimbatore South	Coimbatore	1
9	Dharmanallur	79.49232	11.461142	Virdhachchalam	Virdhachchalam	1
10	Jambai	79.05406	12.015102	Tirukoyilur	Villuppuram	1
11	Kanchipuram	79.70528	12.837500	Kanchipuram	Kanchipuram	1
12	Karaikadu	79.74585	11.667863	Cuddalore	Cuddalore	1
13	Karur	78.08417	10.964722	Karur	Karur	15
14	Kattupudur	78.21768	10.998153	Trichirapalli	Trichirappalli	1
15	Kaveripattinam	79.85889	11.134167	Sirkali	Nagapattinam	1
16	Keeladi	78.19339	9.856545	Manamadurai	Sivaganga	209
17	Kodumanal	77.52944	11.107500	Perundurai	Erode	991
18	Korkai	78.05500	8.641944	Srivaikuntam	Thoothukkudi	8
19	Madurai (Kovalanpottal)	78.11889	9.918333	Madurai South	Madurai	2
20	Maligaimedu	79.58028	11.803056	Panruti	Cuddalore	8
21	Mangudi	77.51361	9.360278	Sankarankoil	Tirunelveli	9
22	Marungur	79.40028	11.461944	Panruti	Cuddalore	3
23	Mathagam	78.96667	10.033333	Aranthangi	Pudukottai	1
24	Mayiladumparai	78.31333	12.420000	Krishnagiri	Dharmapuri	2
25	Palayarai	79.35000	10.933333	Kumbakonam	Thanjavur	1
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27	Pattaraiperumpudur	79.82372	13.151931	Tiruvallur	Tiruvallur	14
28	Periyathadakam	76.85417	11.065549	Periyanayakkanpalayam	Coimbatore	1
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31	Ravimangalam	77.44361	10.410252	Palani	Dindugul	1
32	S.Pappinayakkanpatti	77.71389	9.816111	Peraiyur	Madurai	1
33	Salaiyur	77.11235	11.143856	Palladam	Coimbatore	1
34	Sivakasi	77.79037	9.458915	Sivakasi	Virudhunagar	1
35	Sivakalai	77.97810	8.638710	Sri Vaikundam	Thuthukudi	1

Sr. No.	Site	Long.	Lat.	Taluk	District	Total
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37	T.Kallupatti	77.85389	9.719444	Peraiyur	Madurai	1
38	Teriruveli	78.62508	9.320379	Mudukulathur	Ramanathapuram	7
39	Uraiyur (Tiruchirappalli)	78.67611	10.837778	Srirangam	Tiruchirappalli	21
40	Vallam	79.06528	10.716389	Thanjavur	Thanjavur	4
41	Vedapatti	76.89231	11.002400	Coimbatore South	Coimbatore	1
	Total					1464

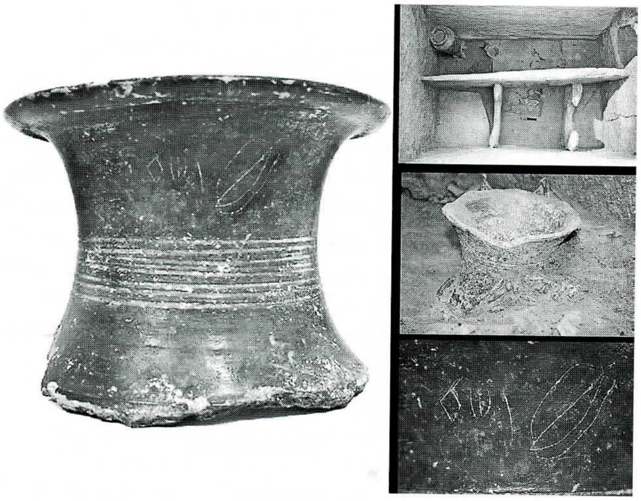


Fig. 4: Ring stand inscribed with Tamil-Brahmi reading *va-y-ra* recovered at Porunthal

beads made of quartz, shell, garnet and terracotta. Bangle pieces were made of glass and shells. The terracotta objects like ear lobes, earrings, games men, hook, hopscotch, spindle whorl, ball and cart-wheel are some of the interesting objects recovered from these cuttings. In case of metal objects, iron arrowheads, knives and nails were collected sparingly. Likewise, a copper ring and a bell were also collected. Two pendants, one made of gold and other of glass, were unearthed. Among the weights, made of quartz and ivory, were noteworthy (Rajan and Yathees Kumar 2014; Rajan *et al.* 2014: 62-85).

Excavation of Graves

The graves, consisting of more than 60 circles, were noticed 2.5 km west of the habitation mound at the foothill of *Tannasiyappanmalai.* In total, four graves (one in 2009 and remaining three in 2010) were opened. Among the four, two are transepted cists (Meg. I and II) placed at the centre of the stone circle. The remaining two are double cists (Meg. III and IV). Both the varieties had a passage on the east. The rectangular transepted cist (Meg. I and Meg. II) had two chambers on its northern and southern side. The northern chamber of the transepted cist (Meg. I) excavated in 2009 yielded a ring stand with letters reading *va-y-ra* in Tamil-Brahmi script (Fig. 4). Paddy grains collected from a four-legged jar placed close to this inscribed ring stand were dated to 2440±30 BP i.e., 490 BCE (cal. 520 BCE). For the first time, an AMS date was obtained for a grave that is associated with the Tamil-Brahmi script (Fig. 5). Till 2009, the

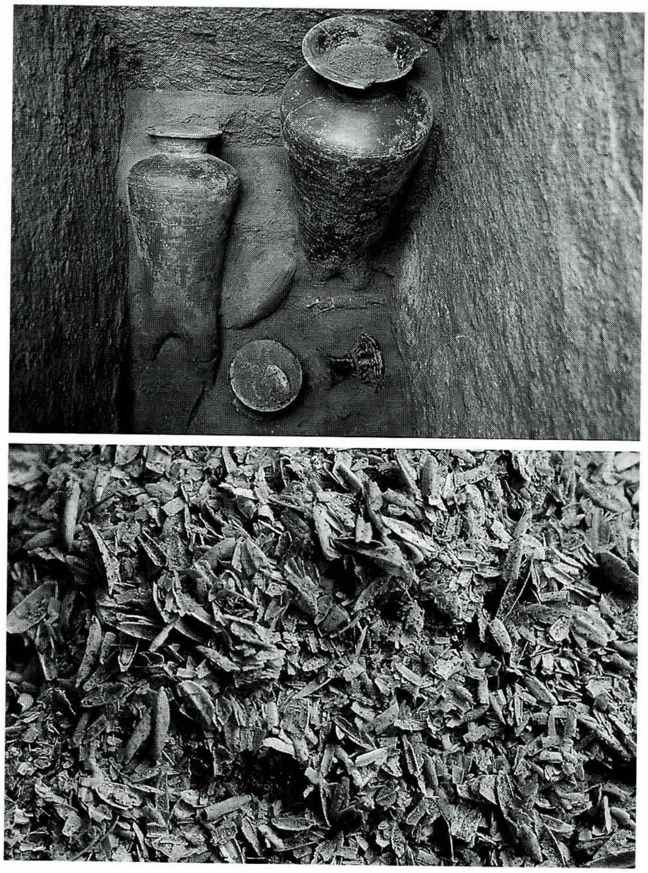


Fig. 5: Four-legged jar containing paddy placed in a cist at Porunthal

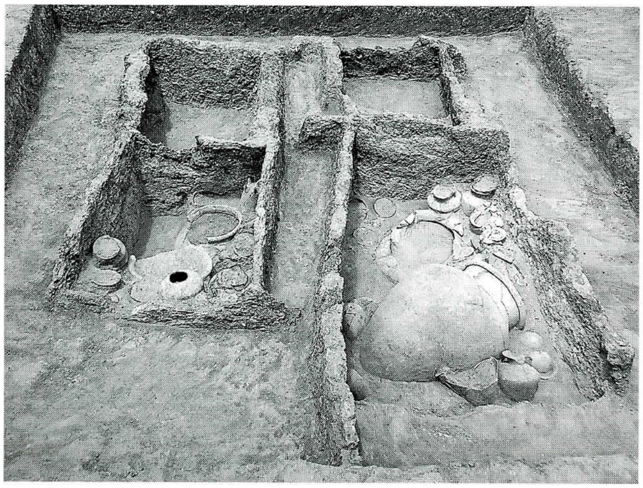


Fig. 6: Double cist with grave goods exposed at Porunthal

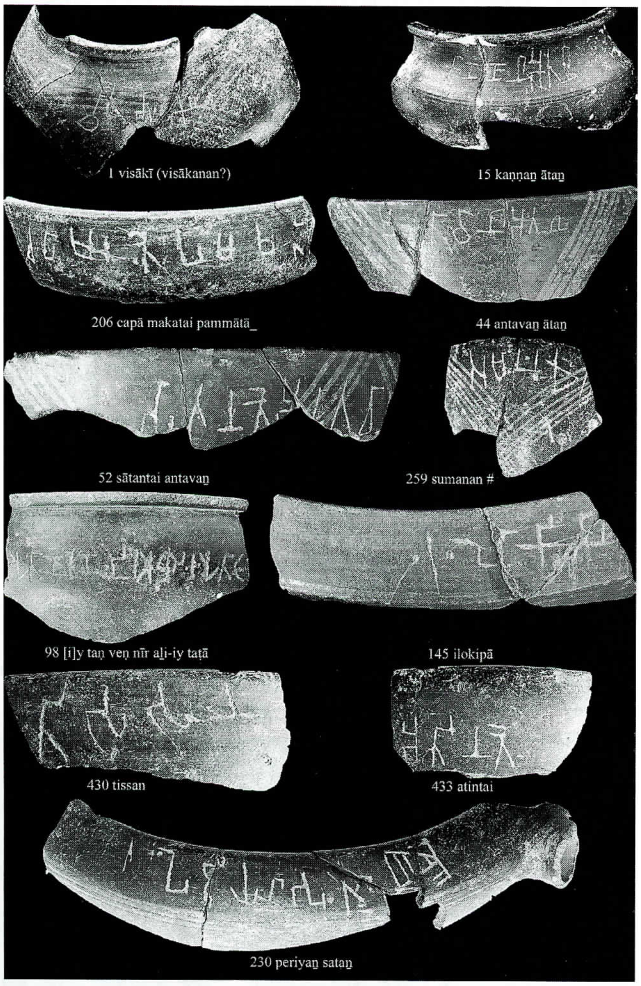


Fig. 7: Tamil-Brahmi inscribed potsherds unearthed at Kodumanal

Tamil-Brahmi script was dated based on palaeography, orthography, linguistic and stratigraphy in Tamil Nadu and was generally dated to the third century BCE. But, the present AMS date has pushed the origin of Tamil-Brahmi two hundred years earlier to Ashoka. Subsequently, paddy grains recovered from another grave Meg. IV (a double cist opened in the year 2010) were dated to 2400 ± 30 BP (450 BCE) (Fig. 6). These two dates 490 BCE (cal. 520 BCE) and 450 BCE (cal. 410 BCE) urged us to have a relook at the introduction of the Tamil-Brahmi script. To further strengthen the scientific dates obtained at Porunthal, it was decided to revisit the site again at Kodumanal as it yielded 991 Tamil-Brahmi inscribed potsherds till December 2020.

Kodumanal evidence

Initially, the Kodumanal inscribed potsherds were dated based on stratigraphy. Subbarayalu (2008: 209-248) dated these inscribed potsherds between the middle of the third century BCE and the middle of the third century CE. Rajan (2009: 57-94) revised the date and pushed it back to fourth century BCE based on the occurrence of quite a number of Tamil-Brahmi inscribed potsherds below the cultural layer yielding the Rouletted ware, Northern Black Polished ware and Punch-Marked coins. All these dates were assigned before the findings of Porunthal excavations. The two AMS dates of 490 BCE (cal. 520 BCE) and 450 BCE (cal. 410 BCE) obtained at Porunthal thus required a revisitation of the dates of Kodumanal (Rajan and Yathees Kumar 2013: 279-285; 2014: 62-85, 271-276). Therefore, it was decided to re-excavate the site and collect samples from well-stratified contexts to fix the date. At the excavations conducted during the field seasons of 2012 and 2013, five samples were collected at the depth of 15 cm, 60 cm, 65 cm, 85 cm and 120 cm in a well established archaeological stratigraphy, and they yielded uncalibrated dates of 200 BCE (cal. 200 BCE), 275 BCE (cal. 380 BCE), 300 BCE (cal. 370 BCE), 330 BCE (cal. 380 BCE) and 408 BCE (cal. 480 BCE), respectively. The time range falls between 200 BCE and 408 BCE (cal. 200 BCE and 480 BCE)

At Kodumanal, the total cultural deposit yielding 991 Tamil-Brahmi inscribed potsherds was 185 cm (Fig. 7). The said date between the second century BCE and the fifth century BCE was assigned to the samples collected from the cultural deposit that falls between 15 cm and 120 cm. There is still 65 cm thick cultural deposit containing Tamil-Brahmi inscribed potsherds below this dated level which could be easily dated to another century thereby taking the earliest deposit to the middle of the sixth century BCE. Thus, the AMS dates obtained from Porunthal and Kodumanal generated a greater amount of interest among the scholars to go for more dates from their excavated sites such as Alagankulam, Adichchanallur, Keeladi and Kodumanal.

AMS dates till December 2020

The recent AMS dates obtained for the samples collected from the excavations conducted at Porunthal, Alagankulam, Keeladi, Kodumanal, Adichchanallur, Thelunganur and Mangudi provided new insights to understanding the Iron Age and Early Historic phase of Tamil Nadu in a chronological scale. From these sites, Thelunganur and Mangadu, AMS samples were collected from steel and iron swords respectively unearthed from disturbed graves, and the two samples found at Adichchanallur from an excavated urn burial, all belonging to the Iron Age. The other samples came from Early Historic phase of the remaining sites. In total, 45 AMS dates were obtained of which 4 samples were contaminated and the remaining 39 samples provided excellent results (Table 3). The chronological and cultural significance of these radiometric dates with respect to each site and the important cultural features that emerged when analyzing the AMS dates have been highlighted below.

1. Nearly 1571 Tamil-Brahmi inscriptions engraved on caves, potsherds, memorial stones, seals, coins and other artefacts were reported from Tamil Nadu.
2. Of the 1571 inscriptions, nearly 1464 were Tamil-Brahmi inscribed potsherds as on 31st December, 2020. Of these 1464 inscribed potsherds, nearly 991 came from Kodumanal (Tamil University and Pondicherry University – 551, Tamil Nadu State Archaeology – 134 and Archaeological Survey of India – 306).
3. 35 samples were collected from the cultural layers yielding Tamil-Brahmi inscribed potsherds from four archaeological sites such as Porunthal, Alagankulam, Keeladi and Kodumanal.
4. All the calibrated AMS dates fall in the time range of the second century BCE to the sixth century BCE.
5. Of the 35 samples, 27 dates are pre-Ashokan (Ashoka's accession 268 BCE; date of edict 256 BCE) and the earliest date goes back to the sixth century BCE (Table 4).

The chronological significance of Porunthal and Kodumanal were explained above and the remaining sites are elucidated below to understand their cultural significance.

Alagankulam

The Early Historic port located on the left bank of the River Vaigai, but close to its mouth, is one of the extensively excavated sites of Tamil Nadu. It yielded several important archaeological materials reflecting extensive external trade contacts of both national and international nature (Sridhar *et al.* 2005). The occurrence of a considerable number of Northern Black Polished ware, potsherds carrying a Roman ship motif and a human figurine of an African origin, Roman coins, *Terra Sigillata* (*Africana*), Tamil-Brahmi inscribed potsherds having Sri Lankan affinity besides the occurrence of a distinct ceramic popularly called Alagankulam ware/Alagankulam Rouletted ware supports its contacts within and outside India (Fig. 8).

Four samples collected from stratified layers covering the depth range between 90 cm and 611 cm were dated. The four dates obtained from the samples collected at the depth of 90 cm, 138 cm, 348 cm and 370 cm, respectively provided the conventional age of 80 BCE, 180 BCE, 220 BCE and 370 BCE. Thus, the conventional age falls between 80 BCE (2030 ± 30 BP with 92.7% probability) and 370 BCE (2320 ± 30 BP with 90.1% probability). The calibrated dates of the said samples respectively provide a date of cal. 83 BCE (calibrated date falls between 2063 ± 30 and 1898 ± 30 BP) and cal. 398 BCE (calibrated date falls between 2378 ± 30 and 2306 ± 30 cal. BP) (Tables 2 and 3). Thus, the earliest date at Alagankulam goes back to the later part of the 4th century BCE. In total, 73 Tamil-Brahmi inscribed potsherds were reported from the dated layers that fall in the time range between 80 BCE and 370 BCE.

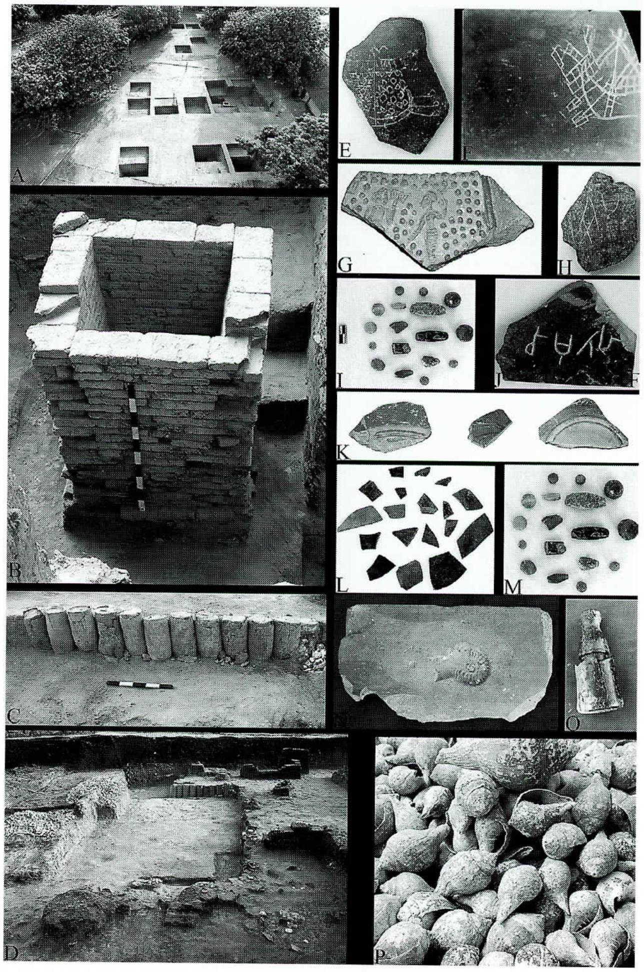


Fig. 8: Artefacts recovered at Alagankulam

Table 3: AMS dates of Tamil Nadu sites

Site	Institution	Sample No.	Trench	Layer and Depth	Conventional Age in BP	Conventional Age in BCE	Calibrated Age (Mid Value)	Calibrated Age (% Probability – Mid-Range)	Calendar Calibration (% Probability)
Kodumanal	ASI	Beta 574973	KDL 2017-18/ ZF7/86	(2) 125 cm	2190±30 BP	240 BCE	269 BCE (361-177 BCE)	269 BCE (95.4%) (361+177=538/2)	(95.4%) 361-177cal. BCE (2310-2126 cal. BP)
Kodumanal	ASI	Beta 574972	KDL2017-18/ZF7/81	(2) 95 cm	2250±30 BP	300 BCE	254 BCE (279-224 BCE)	224 BCE (64.2%) 279 BCE (31.2%) (321+206/2=424/2; 395+347/2=558/2)	(64.2%) 321-206 cal. BCE (2270-2155 cal. BP) (31.2%) 395-347 cal. BCE (2344-2296 cal. BP)
Kodumanal	ASI	Beta 574971	KDL2017-18/ZF7/78	(2) 80 cm	2240 ± 30 BP	290 BCE	318 BCE (367-269 BCE)	269 BCE (70.5%) 367 BCE (24.9%) (323+205=528/2; 390+345=735/2)	(70.5%) 323-205cal. BCE (2272-2154 cal. BP) (24.9%) 390-345 cal. BCE (2339-2294 cal. BP)
Kodumanal	ASI	Beta 574970	KDL2017-18/ZE8/77	(2) 70 cm	2160 ± 30 BP	210 BCE	250 BCE (318-183 BCE)	183 BCE (55.4%) 318 BCE (40%) (259+107=306/2; 358+279=637/2)	(55.4%) 259-107cal. BCE (2208-2056 cal. BP) (40%) 358-279 cal. BCE (2307-2228cal. BP)
Kodumanal	ASI	Beta 574969	KDL2017-18/ZE8/76	(2) 40 cm	2280 ± 30 BP	330 BCE	320 BCE (377-216 BCE)	377 BCE (60%) 262 BCE (33.6%) 216 BCE (1.8%) (403+352=755/2; 297+228=525/2; 221+211=432/2)	(60%) 403-352 cal. BCE (2352-2301cal. BP) (33.6%) 297-228cal. BCE (2246-2177 cal. BP) (1.8%) 221-211cal. BCE (2170-2160cal. BP)
Kodumanal	ASI	Beta 574968	KDL2017-18/ZE8/75	(2) 125 cm, Pit 1SB (2)	2210 ± 30 BP	260 BCE	335 BCE (371-199 BCE)	335 BCE (95.4%) (371+199=670/2)	(95.4%) 371-199cal. BCE (2320-2148 cal. BP)

Site	Institution	Sample No.	Trench	Layer and Depth	Conventional Age in BP	Conventional Age in BCE	Calibrated Age (Mid Value)	Calibrated Age (% Probability – Mid-Range)	Calendar Calibration (% Probability)
Kodumanal	ASI	Beta 574967	KDL 2017-18/ ZD8/69	(2) 60 cm	2220 ± 30 BP	250 BCE	290 BCE (375-203 BCE)	289 BCE (95.4%) (375+203=578/2)	(95.4%) 375-203cal. BCE (2324-2152 cal. BP)
Kodumanal	ASI	Beta 574966	KDL2017-18/ZD8/66	(2) 100 cm	560 ± 30 BP	1390 CE	--	Sample Contaminated	(49.9%) 1307-1362cal. AD (643-588cal. BP) (45.5%) 1385-1429cal. AD (565-521cal. BP)
Kodumanal	ASI	Beta 574965	KDL2017-18/ZB7/48	(2) 49 cm	2230 ± 30 BP	280 BCE	315 BCE (361-266 BCE)	266 BCE (74.6%) 361 BCE (20.8%) (328+204=532/2; 384+339=723/2)	(74.6%) 328-204cal. BCE (2277-2153 cal. BP) (20.8%) 384-339cal. BCE (2333-2288 cal. BP)
Kodumanal	ASI	Beta 574964	KDL2017-18/ YD21/37	(2) 154 cm	300 ± 30 BP	1650 CE	--	Sample contaminated	(69.5%) 1489-1604cal. AD (461-346cal. BP) (25.9%) 1610-1654cal. AD (340-296cal. BP)
Kodumanal	ASI	Beta 574963	KDL2017-18/ YD20/32	(2) 148 cm	380 ± 30 BP	1570 CE	--	Sample contaminated	(61.5%) 1445-1524cal. AD (505-426cal. BP) (33.9%) 1558-1632cal. AD (392-318cal. BP)
Kodumanal	ASI	Beta 574962	KDL 2017-18/ YD20/30	(2) 70 cm	340 ± 30 BP	1610 CE	--	Sample contaminated	(95.4%) 1470-1640cal. AD (480-310calBP)
Kodumanal	Pondicherry University	Beta 351053	KDL-ZD20	15 cm	2150 ± 30 BP	200 BCE	200 BCE (350-220 BCE)	200 BCE (Oxcal-Intel20)	Cal BCE 350 to 290 (Cal BP 2300 to 2240) /Cal BCE 230 to 220 (Cal BP 2180 to 2170) /Cal BCE 210 to 110 (Cal BP 2160 to 2060)

Site	Institution	Sample No.	Trench	Layer and Depth	Conventional Age in BP	Conventional Age in BCE	Calibrated Age (Mid Value)	Calibrated Age (% Probability – Mid-Range)	Calendar Calibration (% Probability)
Kodumanal	Pondicherry University	Beta 349958	KDL-ZD20	65 cm	2250 ± 30 BP	300 BCE	370 BCE (390-210 BCE)	370 BCE (Oxcal-Intel20)	Cal BCE 390 to 350 (Cal BP 2340 to 2300) /Cal BCE 320 to 210 (Cal BP 2270 to 2160)
Kodumanal	Pondicherry University	Beta 330303	KDL-ZD10	80 cm	2280 ± 30 BP	330 BCE	380 BCE (400-230 BCE)	380 BCE (Oxcal-Intel20)	Cal BCE 400 to 350 (Cal BP 2350 to 2300) /Cal BCE 290 to 230 (Cal BP 2240 to 2180)
Kodumanal	Pondicherry University	AA99856	KDL-ZE10	60 cm	2225 ± 41 BP	275 BCE	380 BCE	380 BCE (Oxcal-Intel20)	Cal 389 to 199 BCE (Cal BP 2339 to 2149)
Kodumanal	Pondicherry University	AA 99855 (University of Arizona)	KDL-ZE9	120 cm	2358 ± 40 BP	408 BCE	480 BCE (731-651 BCE)	480 BCE (Oxcal-Intel20)	Cal BCE 731 to 691 (Cal BP 2681 to 2641) /BCE 661 to 651 (Cal BP 2611 to 2601) /Cal BCE 545 to 368 (Cal BP 2495 to 2318)
Porunthal	Pondicherry University	Beta 305904	PTL-MEG-IV	Single time deposit	2400 ± 30 BP	450 BCE	410 BCE (720-400 BCE)	410 BCE (Oxcal-Intel20)	Cal BCE 720 to 700 (Cal BP 2670 to 2650) /Cal BCE 540 to 400 (Cal BP 2490 to 2350)
Porunthal	Pondicherry University	Beta 302854	PTL-MEG-I	Single time deposit	2440 ± 30 BP	490 BCE	520 BCE (750-610 BCE)	520 BCE (Oxcal-Intel20)	Cal BCE 750 to 680 (Cal BP 2700 to 2630) /Cal BCE 670 to 610 (Cal BP 2620 to 2560) /Cal BCE 600 to 410 (Cal BP 2560 to 2360)

Site	Institution	Sample No.	Trench	Layer and Depth	Conventional Age in BP	Conventional Age in BCE	Calibrated Age (Mid Value)	Calibrated Age (% Probability – Mid-Range)	Calendar Calibration (% Probability)
Alagankulam	Tamil Nadu State Archaeology	Beta 494630	ZC3/4	90 cm	2030 ± 30 BP	80 BCE	115 BCE (146-83 BCE)	83 BCE (92.7%) 146 BCE (2.7%) (114+52=166/2; 156+137=293/2)	(92.7%) 114 cal. BCE - 52 cal. AD (2063 - 1898 cal. BP) (2.7%) 156 - 137 cal. BCE (2105 - 2086 cal. BP)
Alagankulam	Tamil Nadu State Archaeology	Beta 494631	ZC3/4	348 cm	2130 ± 30 BP	180 BCE	255 BCE 329-181 BCE)	181 BCE (84.9%) 329 BCE (10.5%) (210+52=262/2; 350+308=658/2)	(84.9%) 210 - 52 cal. BCE (2159 - 2001 cal. BP) (10.5%) 350 - 308 cal. BCE (2299 - 2257 cal. BP)
Alagankulam	Tamil Nadu State Archaeology	Beta 494632	ZC3/4	611 cm	2320 ± 30 BP	370 BCE	329 BCE (398-260 BCE)	398 BCE (90.1%) 260 BCE (5.3%) (429+357=796/2; 286+235=521/2)	(90.1%) 429 - 357 cal. BCE (2378 - 2306 cal. BP) (5.3%) 286 - 235 cal. BCE (2235 - 2184 cal. BP)
Alagankulam	Tamil Nadu State Archaeology	Beta 494633	YD7/4	138 cm	2170 ± 30 BP	220 BCE	242 BCE (258-225 BCE)	258 BCE (92.9%) 225 BCE (2.5%) (360+156=516/2; 134+116= 250/2)	(92.9%) 360 - 156 cal. BCE (2309 - 2105 cal. BP) (2.5%) 134 - 116 cal. BCE (2083 - 2065 cal. BP)
Keeladi	ASI	Beta 454596	YF1/1	250 cm	2170 ± 30 BP	220 BCE	294 BCE (322-265 BCE)	322 BCE (95%) 265 BCE (68%) (325+320=645/2; 200+130=330/2)	(95%) 345-320 BCE (Cal BP 2295 to 2270) and 210-65 BCE (Cal BP 2160 to 2015) ; (68%) 200-130 BCE and 120-110 BCE

Site	Institution	Sample No.	Trench	Layer and Depth	Conventional Age in BP	Conventional Age in BCE	Calibrated Age (Mid Value)	Calibrated Age (% Probability – Mid-Range)	Calendar Calibration (% Probability)
Keeladi	ASI	Beta 454597	YF4/2	195 cm	2200 ± 30 BP	250 BCE	218 BCE (320 – 115 BCE)	320 BCE (90.5%) 115 BCE (68%) (355+285=640/2; 120+110=330/2)	(95%) 355-285 BCE (Cal BP 2305 to 2235) ; 255-245 BCE (Cal BP 2205 to 2195) ; 235-130 BCE (Cal BP 2185 to 2080) ; (68%) 120-110 BCE (Cal BP 2070 to 2060)
Keeladi	ASI	Beta 521458	YE1/2	93 cm	2210 ± 30 BP	260 BCE	285 BCE (371-199 BCE)	285 BCE (95.4%) (371+199=570/2)	(95.4%) 371 - 199 cal. BCE (2320 - 2148 cal. BP)
Keeladi	ASI	Beta 521459	YF1/2	85 cm	2200 ± 30 BP	250 BCE	276 BCE (366-186 BCE)	276 BCE (95.4%) (366+186=552/2)	(95.4%) 366 - 186 cal. BCE (2315 - 2135 cal. BP)
Keeladi	ASI	Beta 521460	YF1/1	145 cm	2090 ± 30 BP	140 BCE	128 BCE (195-42 BCE)	128 BCE (95.4%) (195+42= 237/2)	(95.4%) 195 - 42 cal. BCE (2144 - 1991 cal. BP)
Keeladi	ASI	Beta 521461	ZA1/3	273 cm	2160 ± 30 BP	210 BCE	300 BCE (318-283 BCE)	283 BCE (55.4%) 318 BCE (40%) (259+107=366/2; 358+279=637/2)	(55.4%) 259 - 107 cal. BCE (2208 - 2056 cal. BP) ; (40%) 358 - 279 cal. BCE (2307 - 2228 cal. BP)
Keeladi	ASI	Beta 521462	YB1/3	298 cm	2190 ± 30 BP	240 BCE	269 BCE (361-177 BCE)	269 BCE (95.4%) (361+177=538/2)	(95.4%) 361 - 177 cal. BCE (2310 - 2126 cal. BP)
Keeladi	ASI	Beta 521463	B2/1	386 cm	2200 ± 30 BP	250 BCE	276 BCE (366-186 BCE)	276 BCE (95.4%) (366+186=552/2)	(95.4%) 366 - 186 cal. BCE (2315 - 2135 cal. BP)

Site	Institution	Sample No.	Trench	Layer and Depth	Conventional Age in BP	Conventional Age in BCE	Calibrated Age (Mid Value)	Calibrated Age (% Probability – Mid-Range)	Calendar Calibration (% Probability)
Keeladi	ASI	Beta 489243	YG6/SW	---	2260 ± 30 BP	310 BCE	316 BCE (373-259 BCE)	259 BCE (55.7%) 373 BCE (39.7%) (309+209=518/2; 397+350=747/2)	(55.7%) 309 - 209 cal. BCE (2258 - 2158 cal. BP) (39.7%) 397 - 350 cal. BCE (2346 - 2299 cal. BP)
Keeladi	ASI	Beta 489244	YG4/NW	---	2170 ± 30 BP	220 BCE	192 BCE (258-125 BCE)	258 BCE (92.9%) 125 BCE (2.5%) (360+156=516/2; 134+116=250/2)	(92.9%) 360 - 156 cal. BCE (2309 - 2105 cal. BP) (2.5%) 134 - 116 cal. BCE (2083 - 2065 cal. BP)
Keeladi	Tamil Nadu State Archaeology	Beta 519476	YP7/4	353 cm	2530 ± 30 BP	580 BCE	679 BCE (764-597 BCE)	597 BCE (45.7%) 764 BCE (35.8%) 675 BCE (13.9%) (651+543=1194/2; 797+731=1528/2; 691+660=1351/2)	(45.7%) 651 - 543 cal. BCE (2600 - 2492 cal. BP) (35.8%) 797 - 731 cal. BCE (2746 - 2680 cal. BP) (13.9%) 691 - 660 cal. BCE (2640 - 2609 cal. BP)
Keeladi	Tamil Nadu State Archaeology	Beta 519477	A2/4	315 cm	2230 ± 30 BP	280 BCE	314 BCE (361-266 BCE)	266 BCE (74.6%) 361 BCE (20.8%) (328+204=532; 384+339=723)	(74.6%) 328 - 204 cal. BCE (2277 - 2153 cal. BP) (20.8%) 384 - 339 cal. BCE (2333 - 2288 cal. BP)

Site	Institution	Sample No.	Trench	Layer and Depth	Conventional Age in BP	Conventional Age in BCE	Calibrated Age (Mid Value)	Calibrated Age (% Probability – Mid-Range)	Calendar Calibration (% Probability)
Keeladi	Tamil Nadu State Archaeology	Beta 519478	A3/2	195 cm	1770 ± 30 BP	180 CE	272 CE (275-269 BCE)	275 CE (85.6%) 269 CE (9.8%) (206+345=551/2; 138+200=338/2)	(85.6%) 206 - 345 cal. AD (1744 - 1605 cal. BP) (9.8%) 138 - 200 cal. AD (1812 - 1750 cal. BP)
Keeladi	Tamil Nadu State Archaeology	Beta 519479	A3/2	207 cm	2190 ± 30 BP	240 BCE	269 BCE (361-177 BCE)	269 BCE (95.4%) (361+177=538/2)	(95.4%) 361 - 177 cal. BCE (2310 - 2126 cal. BP)
Keeladi	Tamil Nadu State Archaeology	Beta 519480	A2/1	371 cm (a pit sealed by a layer @200 cm)	2180 ± 30 BP	230 BCE	264 BCE (361-168 BCE)	264 BCE (95.4%) (361+168=529/2)	(95.4%) 361 - 168 cal. BCE (2310 - 2117 cal. BP)
Keeladi	Tamil Nadu State Archaeology	Beta 519481	A3/4	347 cm (a pit sealed by a layer @180 cm)	2140 ± 30 BP	190 BCE	192 BCE (324-67 BCE)	150 BCE (71.4%) 324 BCE (19.4%) 67 BCE (3.3%) 224 BCE (1.4%) (213+88=301/2; 353+296=649/2; 78+57=135/2; 229+220=449/2)	(71.4%) 213 - 88 cal. BCE (2162 - 2037 cal. BP) (19.4%) 353 - 296 cal. BCE (2302 - 2245 cal. BP) (3.3%) 78 - 57 cal. BCE (2027 - 2006 cal. BP) (1.4%) 229 - 220 cal. BCE (2178 - 2169 cal. BP)
Adichchanallur	ASI	Beta 519499	Urn No.58	Single time deposit	2510 ± 30 BP	560 BCE	682 BCE (746-618 BCE)	618 BCE (67.7%) 746 BCE (27.7%) (696+540=1236/2; 791+701=1492/2)	(67.7%) 696-540 cal. BCE (2645-2489 cal. BP) (27.7%) 791-701 cal. BCE (2740-2650 cal. BP)

Site	Institution	Sample No.	Trench	Layer and Depth	Conventional Age in BP	Conventional Age in BCE	Calibrated Age (Mid Value)	Calibrated Age (% Probability – Mid-Range)	Calendar Calibration (% Probability)
Adichchanallur	ASI	Beta 519500	Urn No.105	Single time deposit	2700 ± 30 BP	750 BCE	855 BCE (905-806 BCE)	855 BCE (95.4%) (905+806=1711/2)	(95.4%) 905-806 cal. BCE (2854-2755 cal. BP)
Thelunganur	Pondicherry University	AA 99857	Steel Sword	Grave 1	3089 ± 40 BP	1139 BCE	1334 BCE (1435-1233 BCE)	1334 BCE (95.4%) (1435+1233 = 2668/2)	(93.4%) 1441-1257 cal. BCE (3391-3207 cal. BP)
Thelunganur	Pondicherry University	AA 104832	Same Steel Sword	Grave 1	4208 ± 35 BP	2258 BCE	2806 BCE (2871-2742 BCE)	2871 BCE (30.4%) 2742 BCE (65.1%) (2901+2841=5742/2;2815+2670=5485/2)	(30.4%) 2901-2841 cal. BCE (4851-4791 cal. BP) (65.1%) 2815-2670 cal. BCE (4765-4620 cal. BP)
Thelunganur	Pondicherry University	AA 104113	Arrow head	Grave 1	2835 ± 40 BP	885 BCE	1009 BCE (1111-907 BCE)	1009 BCE (95.4%) (1111+907=2018/2)	(95.4%) 1111-907 cal. BCE (3061-2857 cal. BP)
Mangadu	Pondicherry University	AA 104114	Iron object	Grave 1	3213 ± 34 BP	1263 BCE	1510 BCE (1604-1416 BCE)	1510 BCE (1604+1416 = 3020/2)	(95.4%) 1604-1416 cal. BCE (3554-3366 cal. BP)

Table 4: Century wise occurrence of AMS dates

Century	Year Range	Total No. of AMS Calibrated Dates	Century wise Total No. of Dates
Early Part of 2nd century BCE	100-150 BCE	2	5 (2nd century)
Late Part of 2nd century BCE	151-200 BCE	3	
Early Part of 3rd century BCE	201-250 BCE	3	16 (3rd century)
Late Part of 3rd century BCE	251-300 BCE	13	
Early Part of 4th century BCE	301-350 BCE	6	10 (4th century)
Late Part of 4th century BCE	351-400 BCE	4	
Early Part of 5th century BCE	401-450 BCE	1	2 (5th century)
Late Part of 5th century BCE	451-500 BCE	1	
Early Part of 6th century BCE	501-550 BCE	0	1 (6th century)
Late Part of 6th century BCE	551-600 BCE	1	
Early Part of 7th century BCE	601-650 BCE	0	1 (7th century)
Late Part of 7th century BCE	651-700 BCE	1	
Total		35	35

Keeladi

One of the extensively excavated sites in recent years is Keeladi (Kīḻadi), located on the right bank of River Vaigai about 12 km southeast of Madurai near Tirubhuvanam on the ancient highway leading to Alagankulam, the Early Historic port (Fig. 9). The site was excavated by the Archaeological Survey of India for three seasons in the years 2014-15, 2015-16 and 2016-17. Tamil Nadu State Archaeology Department continued the excavation for three seasons in the years 2018, 2019 and 2020. Nearly ten samples were submitted by Archaeological Survey of India and six samples by the Tamil Nadu State Archaeology Department for radiometric dates (Ramakrishna *et al.* 2018: 30-72; Sivanantham and Seran 2019: 1-60).

In total 16 samples have been dated. The time range of the conventional age falls between 140 BCE and 580 BCE and the calibrated age falls between cal. 128 BCE and cal. 597 BCE. Quite interestingly, of the above 16 samples, 11 samples fall in the calibrated time range between cal. 250 BCE and cal. 300 BCE. All the samples were collected from the Early Historic level. The samples were not collected in the Iron Age level as the priority was given to determine the date of the structures and other artefacts associated with these structures. However, the samples collected in the Iron Age levels during the season of the year 2020 were submitted for AMS dates and results are awaited. The future results may further enlighten the chronology. Based on the available AMS dates, one may conclude that the Early Historic cultural phase of the site could be dated between the middle of the second century BCE to late half of the sixth century BCE. The archaeological records also support this view.

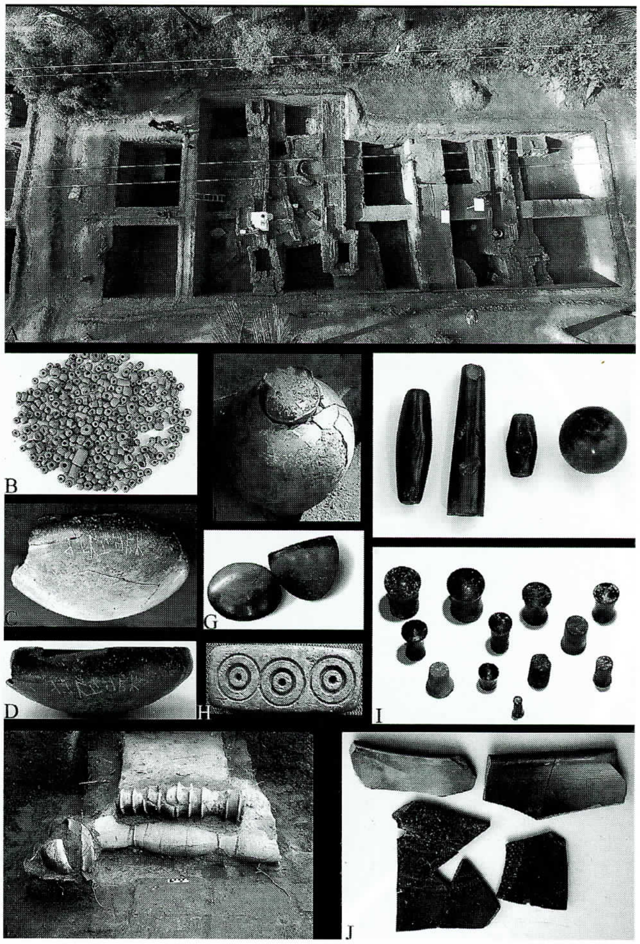


Fig. 9: Artefacts unearthed at Keeladi (Courtesy: Archaeological Survey of India)

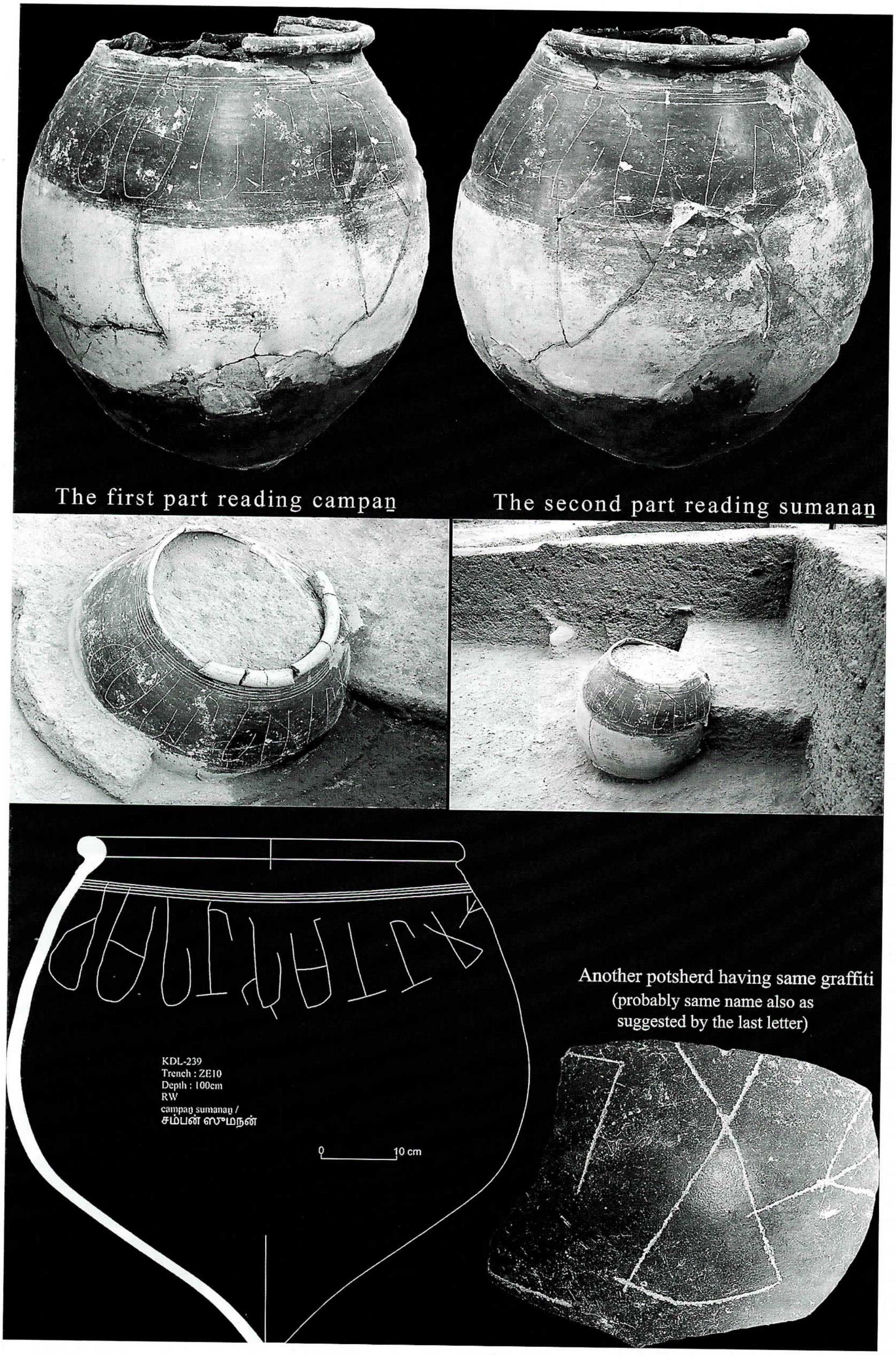

The first part reading campaṉ
The second part reading sumanaṉ
KDL-239
Trench : ZE10
Depth : 100cm
RW
campaṉ sumanaṉ /
சம்பன் ஸுமநன்
0
10 cm
Another potsherd having same graffiti
(probably same name also as
suggested by the last letter)

Fig. 10: Tamil-Brahmi inscribed pot reading *campan-sumanan* unearthed at Kodumanal

Kodumanal

The Early Historic habitation-cum-burial site of Kodumanal lies on the north bank of the River Noyyal, a tributary of Kaveri, in Perundurai Taluk of Erode District, Tamil Nadu (Rajan 2015: 1-56). The habitation mound and the graveyard, respectively cover an area of 15 and 40 ha. The Tamil University excavated the site in the years 1985, 1989, 1990 and 1997; Pondicherry University over two seasons in the years 2012 and 2013; Archaeological Survey of India in the year 2017-18, and Tamil Nadu State Archaeology Department over three seasons in the years 1997 (in association with Tamil University), 1998 and 2020. The excavations yielded extensive data on the nature of the settlement, gemstone industry, method of iron and steel production, weaving and shell industry, type of graves and their architectural features, the types and placement of grave goods, the mode of burial, the usage of graffiti marks and Brahmi characters, the stratigraphical position of the russet coated painted ware, Rouletted ware, Northern Black Polished ware (NBP) and Punch-Marked coins (PMC), the extent of internal and external trade and other interrelated topics. Nearly 991 Tamil-Brahmi inscribed potsherds were collected from the 185 cm thick cultural deposit of the habitation cuttings. Kodumanal is one of the highest inscribed potsherds yielding sites of India (Fig. 10).

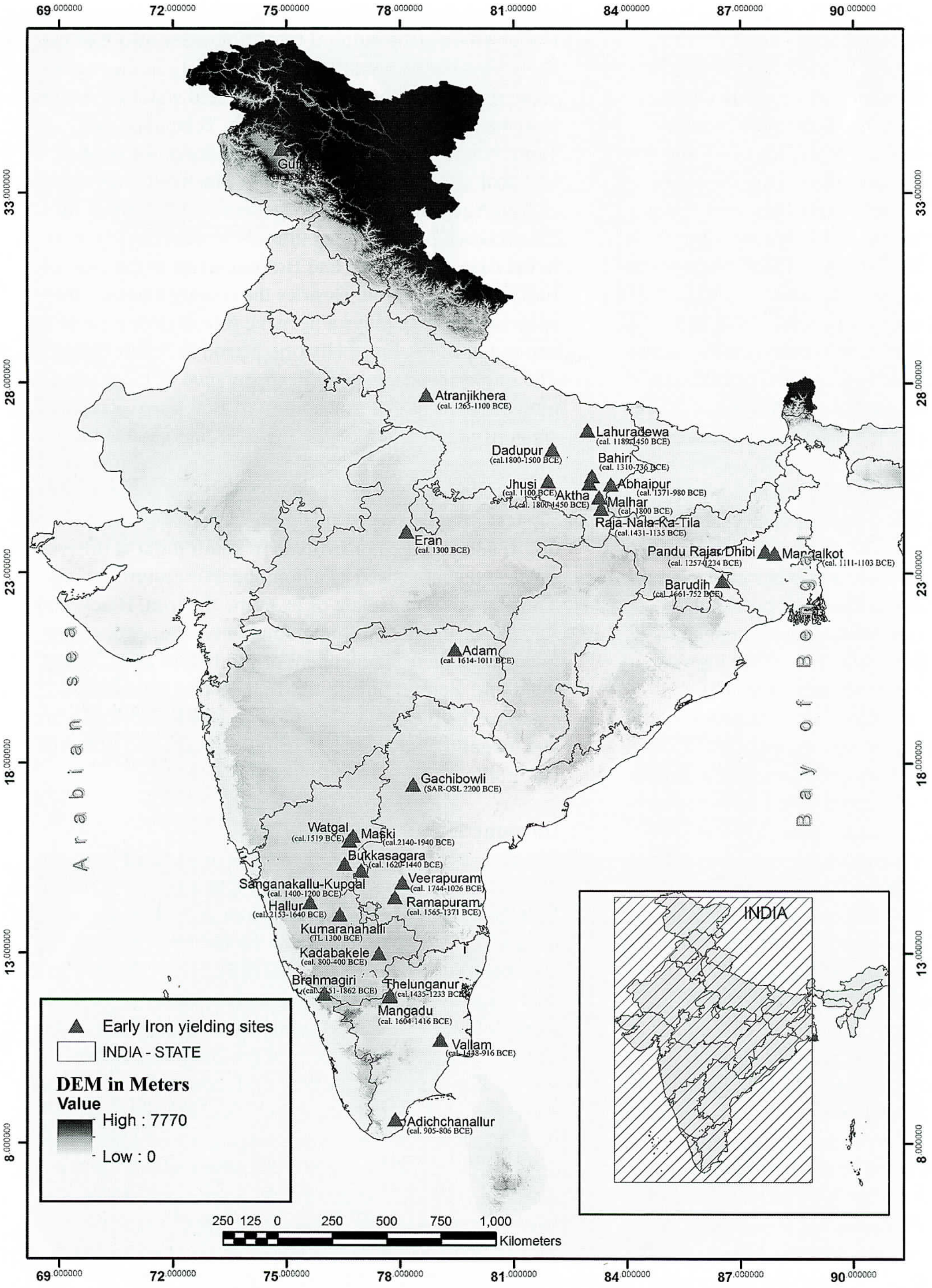
Pondicherry University obtained AMS dates for 5 samples, and Archaeological Survey of India for 12 samples. Of the 17 samples, 13 samples provided excellent dates with a greater amount of consistency. Four samples collected by the ASI from a particular area (YD-Zone) were contaminated. The time range of the conventional age falls between 200 BCE and 408 BCE and the calibrated age falls between cal. 200 BCE and cal. 480 BCE. Quite interestingly, of the above 13 samples, 5 samples fall in the calibrated time range between cal. 250 BCE and 300 BCE and seven samples between cal. 300 BCE and 400 BCE and the remaining one is dated to cal. 480 BCE. Another important feature that needs to be observed is that all these dates arrived at are from the samples collected at the depth between 15 and 125 cm. The total cultural deposit observed at Kodumanal was 185 cm. In the sense, there is about 60 cm undated cultural deposit below the dated deposit of cal. 480 BCE (conventional Age 408 BCE) which could not be dated due to non-availability of samples. If one dates the remaining 60 cm cultural deposit below the dated layer, the bottom-most cultural deposit could easily go back to the sixth century BCE.

Situating Early Historic and Iron Age of Tamil Nadu

These 45 radiometric dates posed two important questions. One is the emergence of the Early Historic period in South India, a transition from the Iron Age, and another is the beginning of the Iron Age. It is one of the important tasks that need to be understood based on recent evidences that emerged in the field of archaeology, epigraphy, numismatics, literature and historical linguistics. Understanding the cultural transition from Iron Age to Early Historic in South India, particularly in the region south of Deccan comprising the present states of southern Karnataka, Kerala, Andhra Pradesh, Telangana and Tamil Nadu, is one of the difficult tasks in the field of archaeology. In the Indian context, the beginning or end of Iron Age/Early Historic is generally determined by the presence of a specific cultural element namely iron in the case of Iron Age and Brahmi script in the case of Early Historic period. Besides the literary sources, the epigraphical data plays a decisive role in determining the beginning of the Early Historic period in South India. The introduction of iron, the appearance of megalithic monuments, and the availability of Black-and-Red ware are considered as the beginning of Iron Age assuming that they were holding contemporary origins and introduced as a cultural package in South India. But, the present evidence suggests that each cultural component has its independent origin and emerged or evolved in south India at different times and synthesised as a homogenous cultural group over time. Let us isolate or examine the iron, Black-and-Red ware, and megalithic monuments independently to understand their independent origin before assimilating them into a common culture. In the same way, let us examine the disappearance of iron, Black-and-Red ware, and megalithic monuments in Tamil Nadu as a potential cultural trait.

Introduction of Iron

Initially, it is believed that iron was introduced through diffusion. But, the analysis of earliest iron pieces that have been encountered in West Asia, Iran and China are mostly meteoritic in origin whereas in the Indian sub-continent it is metallic. The technological difference demonstrated the non-existence of technological connectivity between these cultural zones and leading to the acceptance of the existence of multiple centres of productions. Against this background, the date of introduction of iron in India is examined (Fig. 11). The initial ^{14}C dates obtained in the sites such as Hallur, Ahar, Nagda, Atranjikhera, etc. directed the scholars to place the origin of iron somewhere between 1100 BCE and 1300 BCE (Agrawal 2003; Tewari 2003: 536-544; Chakrabarti 1992; Gaur 1997). The TL-dating of Kumaranahalli pushed the date back a little to 1300 BCE (Agrawal and Joshi 1990: 219-34). The recent radiometric dates obtained at Bukkasagara (Johansen 2014: 256-275), Watgal (Devaraj 1995: 57-74.), Abhaipur, Raja-Nala-Ka-Tila, Ramapuram (Tewari 2003), Sanganakallu-Kupgal (Korisettar 2014: 823-842), Thelunganur and Mangadu (Rajan *et al.* 2017) placed the date between 1300-1700 BCE. Veerapuram (Sastri *et al.* 1984), Raipura (Tripathi 2014), Malhar, Aktha, Dadpur and Gufkral (Tewari 2003) pushed it back to 1800 BCE (Sudyka 2010: 1-43; Tewari 2003: 536-544; Tewari *et al.*



Scientific dates (C14 , AMS, TL and OSL) from Iron Age Sites of India

Fig. 11: Early iron yielding sites of India

2002: 54-62). Maski (Bauer and Johansen 2015: 795-806) and Brahmagiri (Morrison 2005: 257-262) further pushed the origin of iron in India to the second millennium BCE or much earlier in the heartland and peninsular India (Tripathi 2008: 28). The TL and SAR-OSL ages of two pottery samples (GBLD-3, GBLD-4) from the excavated Megalithic burial pits within the campus of Hyderabad University at Gachibowli are 4150-4800 BP and 4000-4510 years BP, respectively. With respect to the datum year (2005) in which the luminescence dating is carried out,

Table 5: Scientific dates (14C , AMS, TL and OSL) from Iron Age sites in India

Site	State	Date	Reference
Kadabakele	Karnataka	cal. 800-400 BCE	Sinopoli 2011
Adichchanallur	Tamil Nadu	cal. 905-806 BCE	Satyamurthy 2007
Jhusi	Utter Pradesh	cal. 1100 BCE	Tewari 2003
Mangalkot	West Bengal	cal. 1111-1103 BCE	Tewari 2003
Lahuradewa	Utter Pradesh	cal. 1189-1450 BCE	Tewari 2003
Atranjikhera	Utter Pradesh	cal. 1265-1100 BCE	Gaur 1997
PanduRajarDhibi	West Bengal	cal. 1257-1234 BCE	Tewari 2003
Eran	Madhya Pradesh	cal. 1300 BCE	Tewari 2003
Kumaranahalli	Karnataka	TL 1300 BCE	Agrawal and Joshi 1990
Bahiri	Utter Pradesh	cal. 1310-736 BCE	Possehl and Rissman 1992
Abhaipur	Utter Pradesh	cal. 1371-980 BCE	Tewari 2003

these ages correspond to 2145 BCE-2795 BCE (TL) and 1995 BCE-2505 BCE (SAR-OSL), respectively (Thomas *et al.* 2008: 781-790). Thus, the series of dates obtained from different ecological zones placed the introduction of iron in India somewhere around the second millennium BCE (Table 5).

Introduction of Steel

The introduction of steel is considered as the technological advancement over and above iron technology. Recent re-investigations of the Indian wootz process have concentrated on material from the known sites of Konasamudram, Nizamabad District, Andhra Pradesh (Lowe 1990: 237-250; Voysey 1832: 245-247) and Gatihosahalli in the Chitradurga District of Karnataka (Freestone and Tite 1986:35-63; Rao 1989:1-6). These investigations have shown the existence of specialised, standardised, and semi-industrial production techniques dating from at least the late medieval period. During field investigations of copper mining and smelting in South India, Jaikishan (2007: 445-460, 2007a: 461-480, 2009) came across several sites in northern Telangana. Srinivasan (2007: 673-96) came across a previously unrecorded archaeometallurgical site at Mel-Siruvalur, South Arcot District, Tamil Nadu. She identified the high-carbon steel at Kodumanal and finally from Kadebakele with a secured date of 880-440 BCE (Srinivasan *et al.* 2009:116-121). Identification of these production centres supports the idea that wootz steel production was relatively widespread in South India and extends the known horizons of this technology further back in time. In addition, Park and Shinde (2013) found some high-carbon steel products among the iron artefacts excavated from the second century BCE to the first century CE site at Junnar in Maharashtra (Park and Shinde 2013: 3822-3833, 2013a: 3991-3998). The available evidence suggests that the transfer of steel technology was quick and widespread. However, the date of the introduction of steel in different parts of South India is yet to be established. The crucible furnace unearthed at Kodumanal is firmly dated to the fifth-sixth century BCE based on radiometric dates (Rajan 2015: 399-416). It is presumed that based on the recent AMS dates, the dates of iron and steel would go beyond the first millennium BCE. In this context, the radiometric dates obtained for iron at Adichchanallur, Mangadu and Thelunganur have added significance.

Two organic samples (paddy) collected from Adichchanallur, one of the extensively excavated urn burial sites of South India, were dated. The rationale for selecting two samples was to determine the chronology of two cultural phases of the graves observed at Adichchanallur (Satyamurthy 2007: 55-66). The early phase contains mostly red ware urns with primary burials and the later phase contains the red ware and Black-and-Red ware urns mostly with secondary burials (Fig. 12). To understand the time range between these cultural phases, the organic samples were carefully chosen to date the material. The sample belonging to the early cultural phase provided a conventional date of 750 BCE (2700 ± 30 BP) and calibrated date between cal. 2854 and 2755 BP with midrange date of cal. 855 BCE (95.4% probability). The sample belonging to the later cultural phase provided a conventional age of 560 BCE (2510 ± 30 BP) and calibrated date between cal.2645 and 2489 BP with mid-range date of cal. 618 BCE. These two dates safely place the existence of habitation at Adichchanallur between the

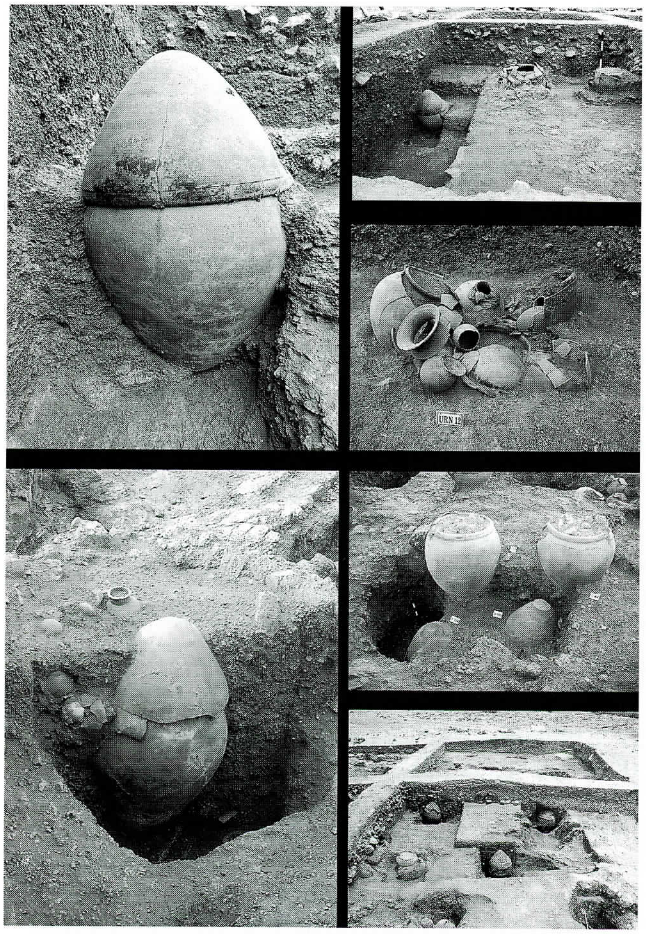


Fig. 12: Urn burials exposed at Adichchanallur (Courtesy: Archaeological Survey of India)

early part of the seventh century BCE and mid-part of the ninth century BCE. The archaeological records also support these dates. This is one of the earliest AMS dates obtained for urn burials in Tamil Nadu. Adichchanallur is also known for the occurrence of a large number of high tin bronze and iron objects. Thus, one can easily assign the date of the ninth century BCE to iron as well as to high-tin bronze.

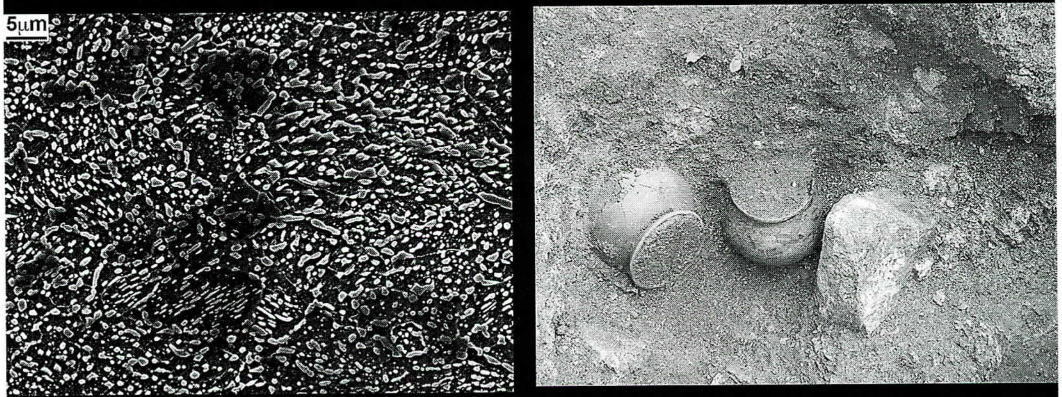
The sample collected from the sword obtained in the grave at Mangadu in Mettur Taluk of Salem District provided the conventional age of 1263 BCE (3213 ± 34 BP) and the calibrated age placed between cal. 1604 and 1416 BCE (cal. 3554-3366 BP) with midrange date of cal. 1510 BCE. Another important archaeological site Thelunganur lies at a distance of 10 km north of Kolaththur, a major revenue village in Mettur Taluk of Salem District, Tamil Nadu (Rajan *et al.* 2017: 52-59; Park *et al.* 2019: 1-13). The graveyard covering an area of 80 ha. of unproductive land is found on the right bank of the River Kaveri (Fig. 8). The metallographic analysis carried out on the sword collected from an Iron Age grave revealed that it was made of ultra high-carbon steel whose carbon concentration is 1.2% or above based on weight fraction (Fig. 13). The radiocarbon analysis of the steel sword yielded two dates of conventional age of 1139 BCE (3089 ± 40 BP) and 2258 BCE (4208 ± 35 BP) respectively and the calibrated age is respectively placed between cal. 3391 and 3209 BP with midrange date of cal. 1334 BCE (sample 1) and between cal. 4765 and 4620 BP with midrange date of cal. 2742 BCE (sample 2). Even if one considers the lowermost date as the possible date of introduction of steel, it could be placed around the mid-part of 14th century BCE. Then, there is a possibility of getting early dates to the iron as it is a normal process before the production of steel. The recent AMS dates obtained for samples collected from the sites such as Raja Nala-Ka-Tila, Malhar, Lahuradewa, Watgal, Gachibowli, Bukkasagara, Thelunganur and Mangadu placed the manufacture of the iron in India somewhere around the second millennium BCE and steel around the 13th/14th century BCE. Thus, the introduction of iron in South India goes back to as early as the second millennium BCE and the Iron Age culture might have begun in South India around the second millennium BCE or still earlier. By keeping these recent developments in mind, the other cultural components like Black-and-Red ware and megalithism are needed to be segregated and need to be dated independently to understand their origin, evolution, and assimilation.

As per the available AMS dates, the megalithic monuments surfaced in the Iron Age level at Mangadu and Thelunganur, and in the Early Historic level at Kodumanal and Porunthal. Therefore, the availability of megalithic monuments in no way helps to determine the beginning or end of Iron Age culture. The introduction of Tamil-Brahmi script alone helps to fix the end of Iron Age and the beginning of the Early Historic period if one considers the introduction of a writing system as the beginning of the Early Historic period. As on today, the available AMS dates suggest that the Iron Age culture survived in Tamil Nadu from the beginning of the second millennium BCE down to the sixth century BCE. The Early Historic period sets its foot around the sixth century BCE in Tamil Nadu subject to revalidation due to the availability of graffiti marks which is considered as one of the writing systems found prior to Tamil-Brahmi writing system. Though we encountered a large number of graffiti inscribed potsherds in a well-stratified context before Brahmi script, the graffiti marks are kept aside in the ambit of the written document as it is considered as a non-deciphered script.

Summary

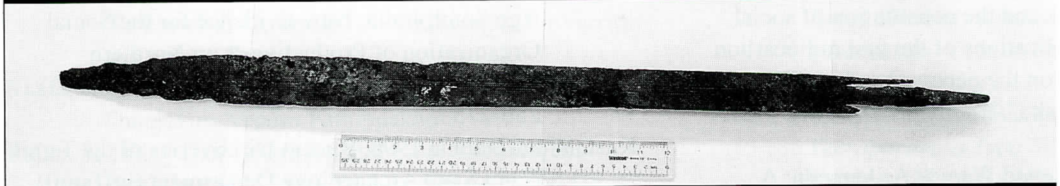
Till date, AMS dates for 45 samples were obtained from the excavated sites of Tamil Nadu (Table 3). Of 45 samples, 6 samples belong to Iron Age which pushed back the introduction of iron to the second millennium BCE as one observed in other parts of India. Of the 39 samples, 4

General view of the graveyard



SEM Micrograh of a steel sword

Grave exposed with arrowheads and pots



Thelunganur : Steel sword

Fig. 13: Graves exposed at Thelunganur

samples were contaminated and the remaining 35 samples collected from the cultural layer belong to the Early Historic phase yielding Tamil-Brahmi inscribed potsherds. Of the 35 samples, 14 dates assigned to pre-Ashokan (i.e., before 268 BCE) and the earliest date goes back to the sixth century BCE. The excavations are in progress at Korkai, Sivakalai, Adichchanallur, Keeladi, Kodumanal, and Mayiladumparai, and all the sites yielded Tamil-

Brahmi inscribed potsherds in the previous excavations. Thus, the future AMS, OSL, Archaeomagnetism, TL and other scientific dates may further consolidate the present position. The availability of extensive brick structures as one observed at Keeladi and Kaveripattinam; the evidence of internal, external, and maritime trade contacts evidenced from the occurrence of beads of carnelian, agate, lapis lazuli, Sri Lankan cat eye, NBP, Punch-Marked coins, amphorae, Arretine, Indo-Pacific monochrome glass beads, names of Prakrit origin, the development of copper, iron, steel, textile, conch and pearl technology, the availability of inscribed coins and seals, formation of trade routes and many other cultural items clearly demonstrate that South India, particularly Tamil Nadu, entered into the Early Historic phase in the sixth century BCE as demonstrated by the recent radiometric dates.

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References

Agrawal, D.P. 2003. *Bronze and Iron Ages in South Asia.* New Delhi: Aryan Books International.

Agrawal, D.P. and G.P. Joshi 1990. Iron Objects from South Indian Megaliths (Karnataka) – A Technological Study and Significance, in *Archaeology in Karnataka* (A. Sundara and K.G. Bhatsoori Eds.), pp. 219-234. Mysore: Directorate of Archaeology and Museums.

Aiyer, K.V. Subrahmanya 1924. The Earliest Monuments of the Pandiya Country and Their Inscriptions, in *Proceedings and Transactions of The Third All-India Oriental Conference*, pp. 275-300. Madras.

Bauer, M. Andrew and Peter G. Johansen 2015. Prehistoric mortuary practices and the constitution of social relationships: Implications of the first radiocarbon dates from Maski on the occupational history of a south India "type site", *Radiocarbon* 57(4): 795-806.

Begley, Vimala 1988. Rouletted Ware at Arikamedu: A New Approach, *American Journal of Archaeology* 92(3): 427-440.

Begley, Vimala 1996. *The Ancient Port of Arikamedu: New Excavations and Researches, 1989-1992*, Pondichéry: Centre d'histoire et d'archéologie, École française d'Extrême-Orient.

Begley, Vimala and Richard Daniel De Puma 1991. Ceramic Evidence for Pre-Periplus Trade on the Indian Coasts, in *Rome and India: The Ancient Sea Trade* (Vimala Begley, and Richard Daniel De Puma Eds.), pp. 157-596. Madison: University of Wisconsin Press.

Chakrabarti, Dilip K. 1992. *The Early Use of Iron in India.* Delhi. New York: Oxford University Press.

Cherian, P.J., G.R. Prasad and K. Shajan 2009. Chronology of Pattanam: A Multi-Cultural Port Site in Malabar Coast, *Current Science* 72(2): 236-240.

Devaraj, D.V., J. Shaffer, C.S. Patil, and K. Balasubramanya 1995. The Watgal Excavations: An Interim Report, *Man and Environment* 20: 57-74.

Ford, L.A. and Robin Coningham 2003. Early Historic Specialization and Standardisation: The Technology of Rouletted Ware and Associated Wares at Anuradhapura, in *South Asian Archaeology 2003* (U. Frankevogt and H.J. Weisshaar Eds.), pp. 393-97. Bonn: Linden Soft.

Freestone, I.C., and M.S. Tite 1986. Refractories in the Ancient and Preindustrial World, in *Ceramics and Civilisation* (W.D. Kingery Ed.), pp. 35-63. Pittsburgh, PA: American Ceramic Society.

Gaur, R.C. 1997. *Studies in Indian Archaeology and Ancient India, Vol.1.* Jaipur: Publication Scheme.

Görsdrof 2001. ^{14}C Datings of the Tissamaharama (Akurugoda) Excavation, in *Ancient Ruhuna: Sri Lankan-German Archaeological Project in the Southern Province,* Vol. 1 (H-J. Weisshaar, H. Roth and W. Wijeyapala Eds.), pp. 279-282. Mainz am Rhein : Von Zabern.

Jaikishan, S. 2007. Survey of Iron and Wootz Steel Production Sites in Telangana, *Indian Journal of History of Science* 44(3): 445-460.

Jaikishan, S. 2007a. Material Evidences for Wootz Steel Production in Northern Telangana, *Indian Journal of History of Science* 44(3): 461-480.

Jaikishan, S. 2009, *Iron and Wootz Steel Industry in Northern Telangana: A Historical Perspective.* Hyderabad: Telangana Jagrithi.

Johansen, Peter G. 2014. Early Ironworking in Iron Age South India: New Evidence for the Social Organization of Production from Northern Karnataka, *Journal of Field Archaeology* 39(3): 256-275.

Kasinathan, Natana 1998. Recent Discoveries of the Tamil Nadu State Archaeology Department (in Tamil), *Avanam, Journal of Tamil Nadu Archaeological Society* 9: 152-154.

Korisettar, R. 2014. Sanganakallu, in *History of India: Protohistoric Foundations,* Vol. 2 (Dilip K. Chakrabarti and Makkhan Lal Eds.), pp. 823-842. New Delhi: Aryan Book International.

Lowe, T.L. 1990. Refractories in High-Carbon Iron Processing: A Preliminary Study of the Deccani Wootz-Making Crucibles, in *Ceramics and Civilization IV: Cross-Craft and Cross-Cultural*

Interactions in Ceramics (W.D. Kingery Ed.), pp. 237-50. Pittsburgh, PA: American Ceramic Society.

Mahadevan, Iravatham 2014. *Early Tamil Epigraphy: From the Earliest Times to the Sixth Century C.E.*, Revised and Enlarged Edition, Vol. 1. Chennai: Central Institute of Classical Tamil.

Morrison, K.D. 2005. Brahmagiri Revisited: A Re-analysis of the South Indian Sequence, in *South Asian Archaeology 2001* (C. Jarrige and V. Lefevre Eds.), pp. 257-262. Paris: Recherche sur les Civilisations-ADPF.

Nagaraja Rao, M.S., Vishnu Mitre and K.R. Alur 1971. *Protohistoric Cultures of the Tungabhadra Valley; a Report on Hallur Excavations*. Dharwar.

Nath, A. 2016. *Excavations at Adam (1988-1992)* 2 Vols. New Delhi: Archaeological Survey of India.

Park, Jang-Sik and Vasant Shinde 2013. Iron Technology of the Ancient Megalithic Communities in the Vidarbha Region of India, *Journal of Archaeological Science* 40(11): 3822-3833.

Park, Jang-Sik and Vasant Shinde 2013a. Technology, Chronology and the Role of Crucible steel as Inferred from Iron objects of the Ancient Site at Junnar, India, *Journal of Archaeological Science* 40(11): 3991-3998.

Park, J.S., K. Rajan and R. Ramesh 2019. High-carbon Steel and Ancient Sword-Making as Observed in a Double-edged Sword from an Iron Age Megalithic Burial in Tamil Nadu, India, *Archaeometry* 62(1): 1-13.

Pavan, Alexia and Heidrun Schenk 2012. Crossing the Indian Ocean before the *Periplus:* a Comparison of Pottery Assemblages at the sites of Sumhuram (Oman) and Tissamaharama (Sri Lanka), *Arab Archaeology and Epigrapy* 23: 191-202.

Possehl, G.L. and P.C. Rissman 1992. The Chronology of Prehistoric India: From Earliest Times to the Iron Age, in *Chronologies in Old World Archaeology* (R. Enrich Ed.), pp. 465-490. Chicago: University of Chicago Press.

Rajan, K. 1997. *Archaeological Gazetteer of Tamil Nadu*. Thanjavur: Manoo Pathippakam.

Rajan, K. 2009. Damiḻi Graffiti and Cave Records, in *Early Historic Tamil Nadu c. 300 BCE-300 CE* (K. Indrapala Ed.), pp. 57-94. Chennai: Kumaran Publishing House.

Rajan, K. 2015. *Early Writing System – A Journey from Graffiti to Brahmi*. Madurai: Pandya Nadu Centre for Historical Research.

Rajan, K. and V.P. Yathees Kumar 2013. New Evidences on Scientific Dates for Brahmi Script as Revealed from Porunthal and Kodumanal Excavations, *Pragdhara* 21-22: 279-295.

Rajan, K. and V.P. Yathees Kumar 2014 *Archaeology of Amaravathi River Valley – Porunthal Excavations*. Delhi: Sharada Publishing House.

Rajan, K., V.P. Yathees Kumar, S. Selvakumar, R. Ramesh and P. Balamurugan 2014. Archaeological Excavations at Porunthal, District Dindugul, Tamil Nadu, *Man and Environment* 38(2): 62-85.

Rajan, K., R. Ramesh and J.S. Park 2017. Recent Evidence of Ultrahigh Carbon Steel from Thelunganur, Tamil Nadu, *Man and Environment* 42(2): 52-59.

Rajavelu, S. 2004. Asokaṉ-BrāhmikkumTamiḻ-Brāhmikkum (Tamil) iṭaiyē kānappaṭum kālanilaiyil āṉa uṟavukaḷ (The chronological relationship between Asokan-Brahmi and Tamil-Brahmi), Paper presented in the *Symposium on the Formative Phase of South India History with special reference to earliest Tamil (Brahmi) writings and Archaeological Discoveries,* Thanjavur: Department of Epigraphy, Tamil University.

Ramakrishna, K.Amarnath, Nanda Kishor Swain, M.Rajesh and N. Veeraraghavan 2018. Excavations at Keeladi, Sivaganga District, Tamil Nadu (2014-2015 and 201-216), *Heritage* 6: 37-72.

Ramesh, K.V. 2006. *Indian Inscriptions – A Study in Comparison and Contrast.* Bangalore: Indian Council of Historical Research.

Rao, K.N.P. 1989. Wootz: Indian Crucible Steel, *Metal News* 11: 1-6.

Sahi, M.D.N. 1979. Iron at Ahar, in *Essays in Indian Protohistory* (D.P. Agrawal and D.K. Chakrabarti Eds.), pp. 365-68. Delhi: B.R. Publishing Corporation.

Sampath, M.D. 2004. Sri Lankan and Tamil Brahmi Scripts – A Comparative Study, Paper presented in the *Symposium on the Formative Phase of South India History with special reference to earliest Tamil (Brahmi) writings and Archaeological Discoveries,* Thanjavur: Department of Epigraphy, Tamil University.

Sastri, T.V.G., M. Kasturi Bai and J.V.P. Rao 1984. *Veerapuram: a Type Site for Cultural study in the Krishna Valley.* Hyderabad: Birla Archaeological & Cultural Research Institute.

Satyamurthy, T. 2007. Adichchnallur: New Discoveries in the light of Rea's Exacavation, *Journal of Indian Ocean Archaeology* 4: 55-66.

Salomon, Richard 1998. *Indian Epigraphy a Guide to the Study of Inscriptions in Sanskrit, Prakrit, and the Other Indo-Aryan Languages*. New York: Oxford University Press.

Schenk, Heidrun 2001. The Development of Pottery at Tissamaharama, *Zeitchriftfür Archäeologie Aussereuropäischer Kulturen* 1: 59-195.

Schenk, Heidrun 2006. The Dating and Historical Value of Rouletted Ware, *Zeitchriftfür Archäeologie Aussereuropäischer Kulturen* 1: 123-52.

Schenk, Heidrun 2014. Tissamaharama Pottery Sequence and the Early Historic Maritime Silk Route Across the Indian Ocean, *Zeitchriftfür Archäeologie Aussereuropäischer Kulturen* 6: 95-118.

Sinopoli, M. Carla 2011. Human Representation in the South Indian Iron Age: A View from Kadebakele, *Man in India* 91: 359-362.

Sivanantham, R. and M. Seran 2019. *Keeladi : an Urban Settlement of Sangam Age on the Banks of River Vaigai.* Chennai: Department of Archaeology, Government of Tamil Nadu.

Sridhar, T.S., D.Thulasiraman, S. Selvaraj and S.Vasanthi 2005. *Alagankulam, an Ancient Roman Port City of Tamil Nadu.* Chennai: Department of Archaeology, Government of Tamil Nadu.

Srinivasan, Sharada 2007. On Higher Carbon and Crucible Steels in Southern India: Further Insights from Mel-siruvalur, Kodumanal and Pattinam, *Indian Journal of History of Science* 42(4): 673-695.

Srinivasan, Sharada, C.M. Sinopoli, K.D. Morrison, R. Gopal, and S. Ranganatham 2009. South Indian Iron and Higher Carbon Steel: With Reference to Kadebakele and Comparative Insights from Mel-Siruvalur, in *Metallurgy and Civilization: Eurasia and Beyond* (Jianjun Mei and Thilo Rehren Eds.), pp. 116-121. London: Archetype.

Sriraman, P.S., R. Ramesh, S. Vetriselvi, S. Sarutha 2020. Kodumanal Excavations (in Tamil), *Sasanam, Bi-Annual Journal of Krishnagiri District Historical Research Centre, Hosur* 2-3: 49-62.

Subbarayalu, Y. 2008. Pottery Inscriptions of Tamil Nadu – A Comparative View, *Airavathi: Felicitation Volume in Honour of Iravatham Mahadevan*, pp. 209-248. Chennai: Varalaru.com.

Subbarayalu, Y. 2014. Early Contacts between the North and the South: An Epigraphical Perspective, in *Explorations in South Indian History* (M.P. Mujeebu Rahman and K.S. Madhavan Eds.), pp. 115-127. Kottayam: Sahithya Pravarthaka Co-operative Society Ltd.

Sudyka, Joanna 2010. The Megalithic Iron Age vulture in South India - Some General Remarks, *Analecta Archaeologica Ressoviensia* 5: 1-43.

Thomas, P.J., P. Nagabhushanam, and D.V. Reddy 2008. Optically Stimulated Luminescence Dating of Heated Materials Using Single-Aliquot Regenerative-Dose Procedure: A Feasibility Study Using Archaeological Artefacts from India, *Journal of Archaeological Science* 35: 781-790.

Tewari, Rakesh 2003. The Origins of Iron Working in India: New Evidence from the Central Ganga Plain and the Eastern Vindhyas, *Antiquity* 77(297): 536-544.

Tewari, Rakesh 2010. Updates on the Antiquity of Iron in South Asia, *Man and Environment* 35(2): 81-97.

Tewari, Rakesh, R.K Srivastava, K.S. Saraswat and K.K. Singh. 2000. Excavations at Malhar, District Chandauli (U.P.) 1999: A Preliminary Report, *Pragdhara* 10: 69-98.

Tewari, Rakesh, R.K Srivastava, and K.K. Singh 2002. Excavation at Lahuradewa, District Sant Kabir Nagar, Uttar Pradesh, *Pragdhara* 32: 54-62.

Tripathi, Vibha 2008. *History of Iron Technology in India: From Beginning to Pre-Modern Times.* New Delhi: Rupa & Co. in association with Infinity Foundation.

Tripathi, Vibha 2014. Recently Discovered Iron Working Site in Vindhya-Kaimur Region, India, *Iron and the Steel Institute of Japan International* 54(5): 1010-1016.

Voysey, H.W. 1832. Description of the Manufacture of Steel in Southern India, *Journal of Asiatic Society of Bengal* 1: 245-47.

Wheeler, R.E.M. 1946. Arikamedu: An Indo-Roman Trading Station on the East Coast of India, *Ancient India* 2: 7-124.